SOUTH CAROLINA GRID IMPROVEMENT PLAN

MAINTAIN BASE AND INCREMENTAL TRANSMISSION AND DISTRIBUTION SYSTEM WORK

MAINTAIN BASE TRANSMISSION AND DISTRIBUTION SYSTEM WORK

WHAT WE DO AS MAINTAIN BASE WORK

Safety	Load Service	Reliability	Environment
Pole inspections and pole inspection repairs	New line extensions	Pole inspections and pole inspection repairs	Critical infrastructure review near waterways (210 gallons of oil within 100 ft. of active waterway)
End of life pole replacement	Line capacity upgrades/additions	End of life pole replacement	Surface mounted equipment inspections and maintenance
Surface mounted equipment inspections and maintenance	Substation capacity upgrades/additions	IR inspections	Below surface mounted equipment inspections and maintenance
Below surface mounted equipment inspections and maintenance	Circuit phase additions	Capacitor, regulator, recloser maintenance work	Capacitor, regulator, and recloser maintenance work
Voltage contact inspections and follow-up work	Corrective maintenance	Deteriorated conductor replacement	Corrective maintenance
Top of pole inspection & follow-up work		Top of pole inspection & follow-up work	Outage follow-up
Corrective maintenance		UG cable testing and follow-up	Proactive replacement of pad mount transformers
Outage follow-up		Vegetation maintenance program and danger tree program	
		Declared protection zones	

MAINTAIN BASE TRANSMISSION AND DISTRIBUTION SYSTEM WORK

WHAT WE DO AS MAINTAIN BASE WORK

Safety	Load Service	Reliability	Environment
		System protection work	
		UG cable repair, replacement and injection programs	
		Corrective maintenance	
		Outage follow-up	
		Declared protection zones	

MAINTAIN BASE TRANSMISSION AND DISTRIBUTION SYSTEM WORK

WHY WE DO IT AS MAINTAIN BASE WORK

Safety	Load Service	Reliability	Environment
Required by law, rule, regulation, code	Required to serve all existing and new load in our territory via standard design	Required by law, rule, regulation, code	Required by law, rule, regulation, code
Public and worker safety is top priority for the Company	Required to account for mandatory reserves, margins, system impacts	National sources on what customers expect as minimum standards	Environmental protection and safety is top priority for the Company
High consequences with adverse occurrences	High consequences with adverse occurrences	Local sources on what customers expect as minimum standards	High consequences with adverse occurrences
Industry standard expectations	Industry standard expectations	Historical level of service that customers have been provided	Industry standard expectations
High stakeholder acceptance	High stakeholder acceptance	Solving for reliability as a system and not for individual areas or certain customer types	High stakeholder acceptance
		Direct feedback on what our customers care about	
		Recognition that a certain level of outages and interruptions is acceptable to avoid making the system too costly	

SOUTH CAROLINA GRID IMPROVEMENT PLAN

MEGATRENDS IMPACTING SOUTH CAROLINA

TRENDS IN OUR SERVICE TERRITORY

In the context of the emerging distributed electric system, Duke Energy has recognized multiple trends and facts that warrant recognition and analysis.

I Threats to grid infrastructure

II Technology advancements – Renewables and DER

III Environmental trends

IV Impact of weather events

V Grid improvement

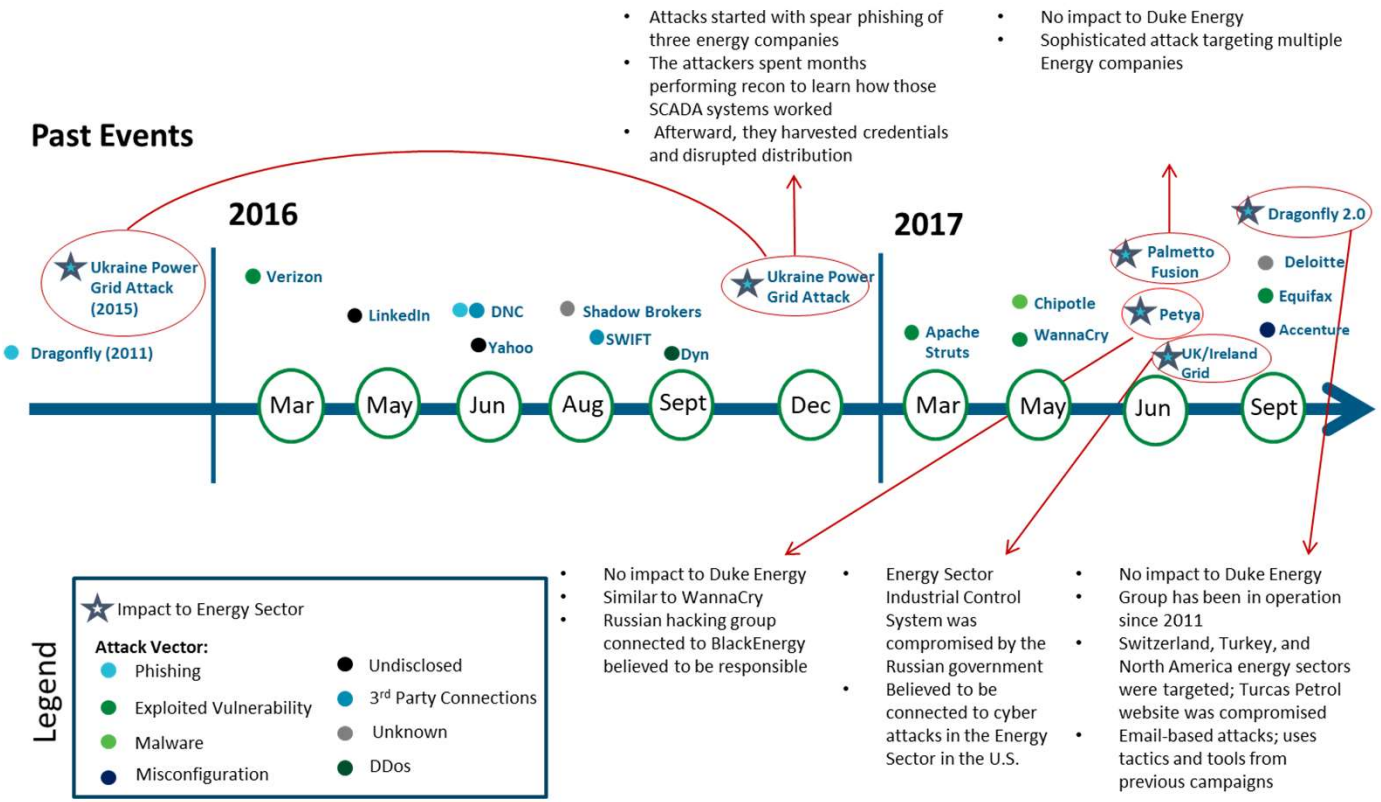
VI Concentrated population growth

VII Customer expectations

I. THREATS TO GRID INFRASTRUCTURE

What is happening?

- Purposeful threats, both physical and cyber, to the electric grid are on the rise worldwide

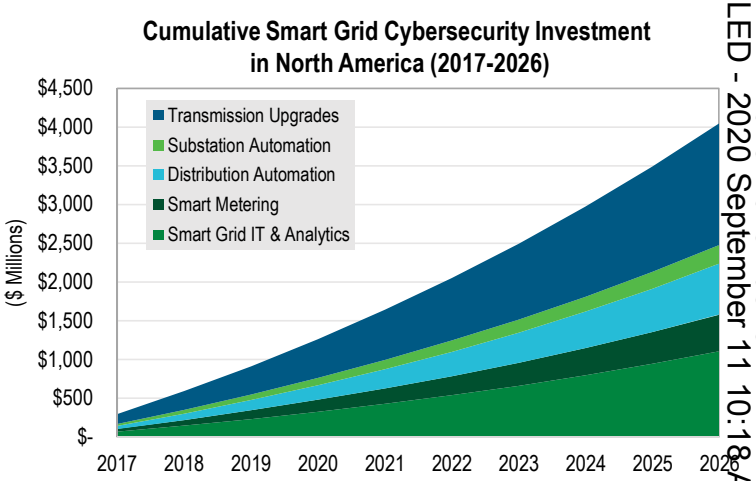


Source: Duke Energy[1]

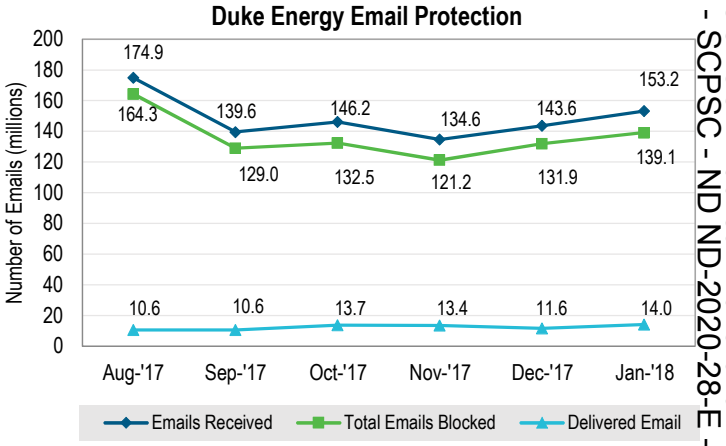
I. THREATS TO GRID INFRASTRUCTURE

What is happening?

- Grid cybersecurity investment expected to grow from $300 million in 2017 to $4 billion by 2026[2]
- Increasing points of entry: as of November 2017, an estimated 378 million Internet of Things (IoT) devices were vulnerable to hacking[3]
- Ukrainian power grid attacks in 2015 and 2016 and more recent ransomware attacks driving utilities to expand beyond compliance-based management practices[4]
    - Industrial Control Systems Cyber Emergency Response Team estimates a similar incident in the US would result in damages totaling between $243 billion and $1 trillion[5]
- Cyber attacks impacting Southeast municipalities and utilities
    - Ransomware attacks in Mecklenburg County (Charlotte) and Atlanta impacted key government services including bill payments[6]
    - North Carolina fuel distribution company experienced $800,000 cyber heist[7]
    - Duke Energy protection solutions currently blocking +90% of incoming emails[8]



Source: Navigant Research Cybersecurity for the Digital Utility[9]



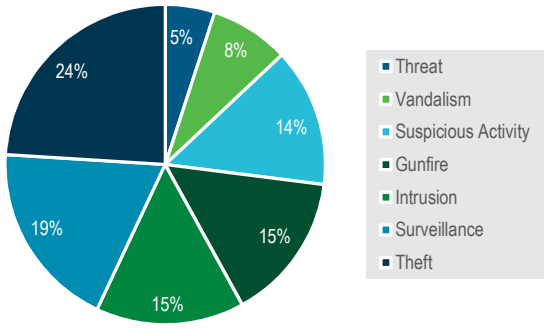
Source: Duke Energy[10]

I. THREATS TO GRID INFRASTRUCTURE

What is happening?

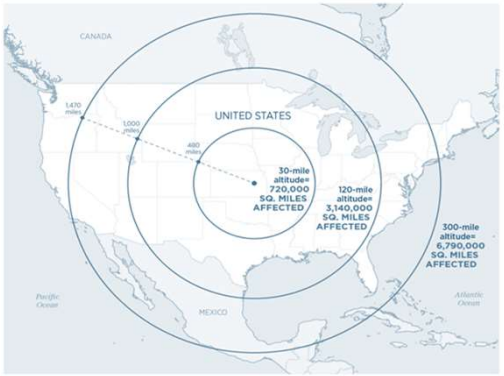
- Electricity Information Sharing and Analysis Center (E-ISAC) assesses that there will be an increase in theft, especially in areas more negatively impacted by socio-economic issues[11]
  - Theft was the top physical threat to the grid in 2017[12]
- The number of terrorist attacks is increasing
  - Physical/sniper attack on PG&E transmission station damaged 17 substation transformers, caused $15 million in damages, and led to $100 million in physical security investments[13]
- Electromagnetic Pulse (EMP) generated at an altitude of 30 miles above the earth can severely damage electronics within an area of about 720,000 square miles[14]
  - Currently there is limited protection to address consequences of EMP-like events[15]
  - Have potential to cause wide-scale long-term losses with economic costs[16]
  - Cost of damage from the most extreme solar event is estimated to cost $1 trillion-$2 trillion with recovery time of 4-10 years[17]

Breakdown of Physical Security Incidents for 2017



Source: NERC[18]

Potential Magnitude of EMP Events



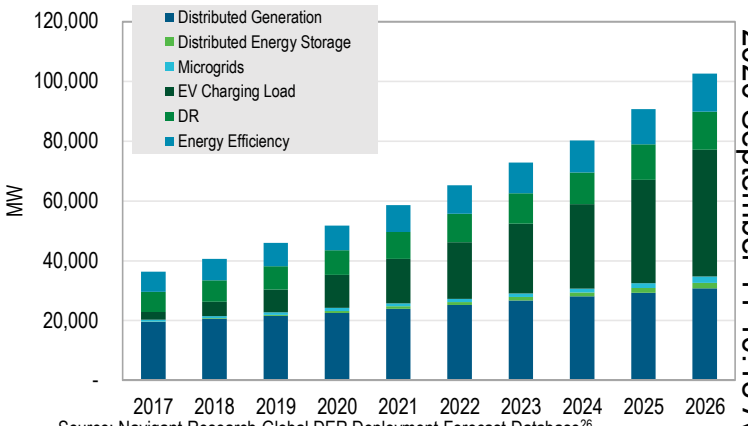
Source: The Heritage Foundation[19]

II. TECHNOLOGY ADVANCEMENTS – RENEWABLES AND DER

What is happening?

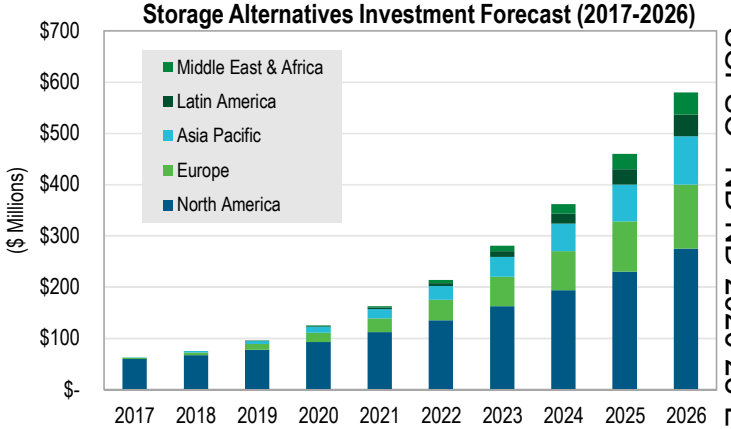
- Distributed energy resources (DER) expected to grow eight times faster than net new centralized generation in the next 10 years globally[20]
  - Distributed generation, including solar PV, remains a dominant contributor to this forecast
  - EVs and EV charging are the fastest growing segments
- Spending on energy storage solutions and alternatives is forecasted to increase at an annual rate of 18% over the next 10 years in North America[21]
- Renewables and DER becoming significant capacity resource for Duke Energy in South Carolina
  - Recent South Carolina Integrated Resource Plan (IRP) includes two times the capacity from renewable resources, energy efficiency, and demand-side management, increasing from 8% in 2019 to 16% in 2033[22]
  - Duke Energy Carolinas (DEC) customer-scale solar program reached 40 MW cap in 13 months (10/15 -11/16)[23]
  - Duke Energy Progress (DEP) customer-scale solar commitments ~60% of 26 MW cap[24]
  - Solar advocates proposing cap increases, DEC has proposed cap increase
  - The Duke Energy South Carolina interconnection queue has +300 requests totalling over 6,300 MW[25]

Global DER Capacity Forecast (2017-2026)



Source: Navigant Research Global DER Deployment Forecast Database[26]

Storage Alternatives Investment Forecast (2017-2026)



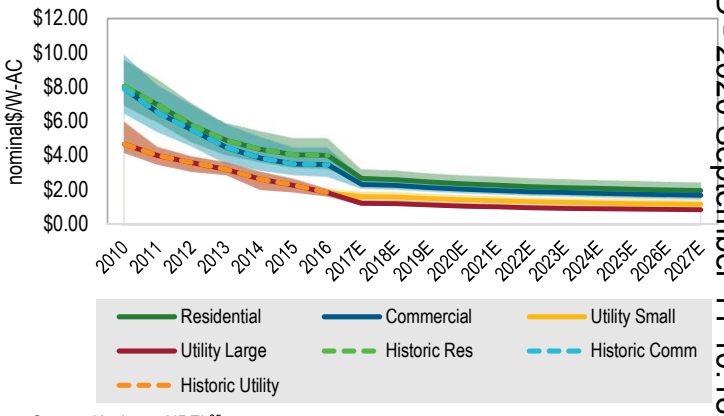
Source: Navigant Research[27]

II. TECHNOLOGY ADVANCEMENTS – SOLAR PV

What is happening?

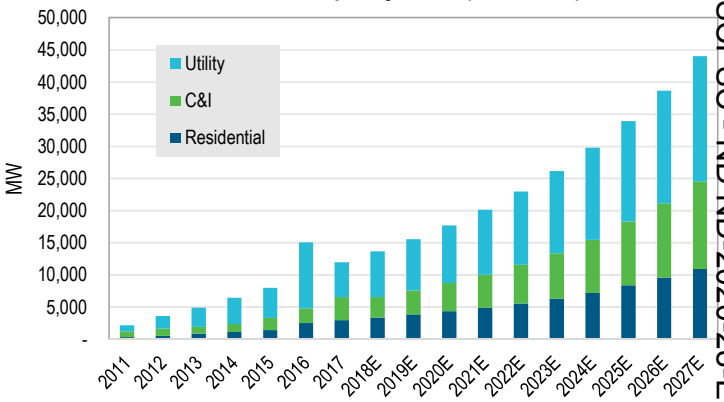
- Solar PV is becoming increasingly competitive[28]
  - Cost of utility-scale solar has dropped 66% since 2010 and is projected to decline by 3.6% per year in the next 10 years[29]
  - Cost of distributed solar has dropped 67% since 2010 and is projected to decline by 3.1% per year in the next 10 years[30]
- Solar PV efficiency has increased which lowers overall installed cost by minimizing the number of panels needed to achieve the same output.
- Module efficiency has increased 2% annually since 2007[31]
  - Manufacturing is shifting to higher efficiency monocrystalline panels
- Distributed solar PV installations are projected to increase in South Carolina
  - South Carolina was ranked 8th in the nation for the most cumulative installed solar capacity in 2017[32]
  - ~6,300 projects totaling ~100 MW have been installed to date[33]
  - Installed capacity in South Carolina is projected to increase 9% per year 2018-2026[34]

Solar PV Cost Declines (2010-2027)



Source: Navigant, NREL[35]

Historical and Forecasted Annual Solar PV Installed Capacity in US (2011-2027)



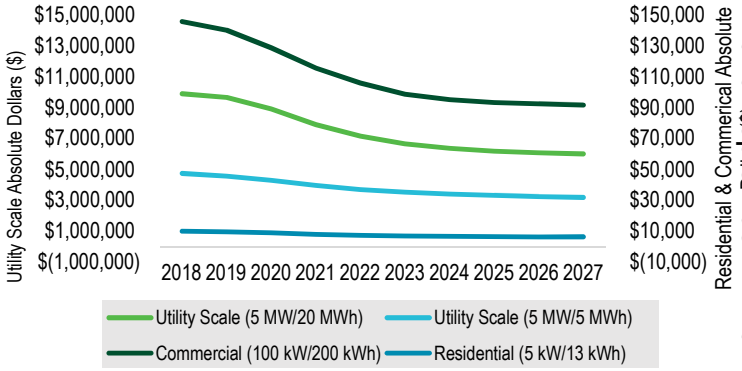
Source: Navigant Research Market Data: Global Distributed Solar PV[36]

II. TECHNOLOGY ADVANCEMENTS – BATTERY STORAGE

What is happening?

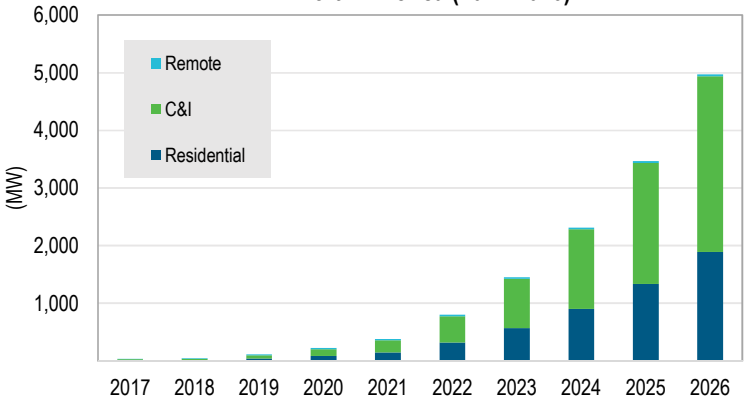
- Battery storage costs expected to decline over the next 10 years in the US
  - Cost of utility-scale storage is projected to decline by 5.4% per year, and utility investment in storage is likely to increase to provide more grid flexibility[37]
  - Cost of distributed storage projected to decline by 5% per year[38]
- Storage installations are projected to increase 2018-2027 in North America:
  - 35% per year for utility-scale[39]
  - 25% per year for distributed storage[40]
- Storage is increasingly installed co-located with renewable energy. Installed capacity of solar plus storage is projected to increase in North America:
  - 57% per year 2018-2026 for utility-scale[41]
  - 76% per year for distributed storage[42]

Li-Ion Battery Storage System Capital Cost Forecast (2018-2027)



Source: Navigant Research Large Commercial and Industrial Energy Storage [43]

Annual Solar PV + Storage Power Capacity and Revenue in North America (2017-2026)



Note: Remote, off-grid solar plus storage typically serves loads of 5 kW or less in remote areas without grid access

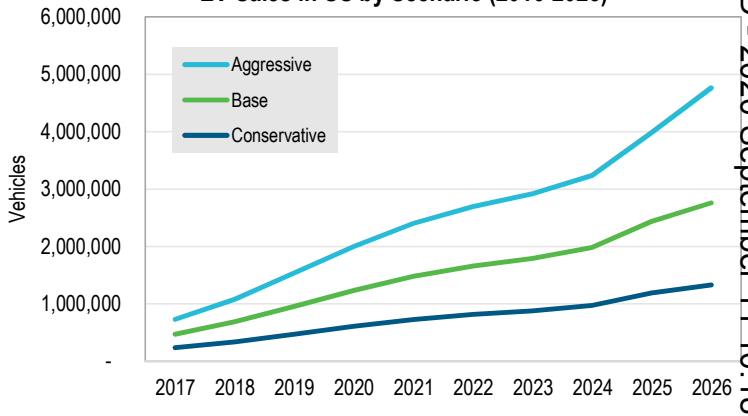
Source: Navigant Research Distributed Solar PV plus Energy Storage Systems[44]

II. TECHNOLOGY ADVANCEMENTS – ELECTRIC VEHICLES

What is happening?

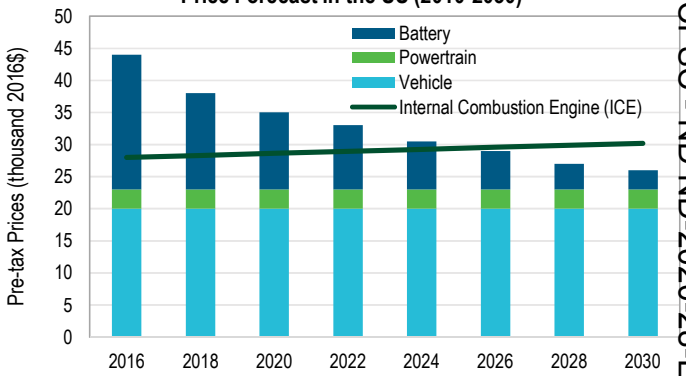
- Cost of EVs has decreased by 80% since 2010[45]
- EVs expected to be competitive with internal combustion engine (ICE) vehicles by 2030[46]
- General Motors announced all-electric, zero emissions future with 20 fully electric models by 2023[47]
    - "General Motors believes electric, self-driving, connected vehicles and shared mobility services will transform how we get around, and we are drawing the blueprint to advance our vision of a world of zero crashes, zero emissions, and zero congestion." – General Motors
- EV adoption is projected to increase
    - By 2027, there will be near 58M PEVs[48]
    - By end of 2018, over 5M PEVs will be on roads globally[49]
    - The number of US residential charging locations is estimated to reach ~6 million by 2025[50]
    - The global market of EVs should see continued sales growth at around 38% through 2020[51]
- Currently, over 2,144 PEVs are on South Carolina's roads today[52]
    - South Carolina recommends in its State Energy Plan to focus on assessing interest in government fleet adoption of alternative fuels and ultimately encourage the development of statewide goals and incentives to promote alternative fuels[53]

EV Sales in US by Scenario (2016-2025)



Source: Navigant Research EV Geographic Forecasts[54]

Battery Electric Vehicle (BEV) and Internal Combustion Engine (ICE) Price Forecast in the US (2010-2030)



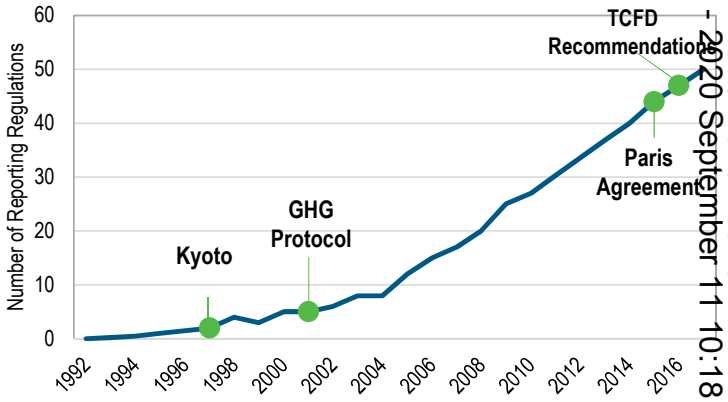
Note: Vehicle prices based on medium segment price
Source: Bloomberg New Energy Finance[55]

III. ENVIRONMENTAL COMMITMENTS

What is happening?

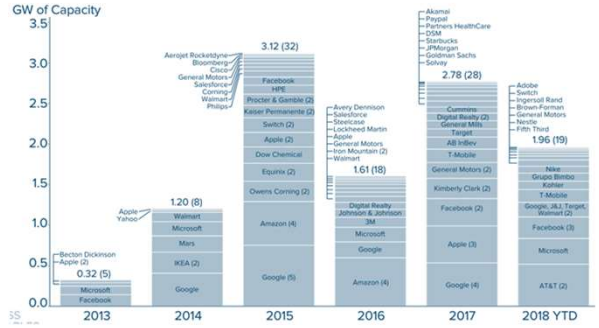
- Broad international commitment and pressure to reduce carbon emissions
- Cyclical federal environmental policy commitments (COP 21, CPP) but implementation of federal energy efficiency standards (transportation, lighting, etc.) underway
- Corporations making commitments and demanding renewable options
  - ~48% of Fortune 500 companies have sustainability and renewable energy commitments[56]
  - Leading SC corporations have set sustainability goals, including BMW, Michelin, Milliken, Walmart, Fujifilm, Ingersoll Rand, Owens Corning, Sealed Air Corporation, and VF Corporation
  - 488 companies taking science-based climate action and 133 have approved targets[57]
  - 75 companies have committed to Corporate Renewable Energy Buyers' Principles with goal to "work with utilities and regulators to expand choices for buying renewable energy"[58]
- States and cities setting goals for renewables, low carbon transportation, and energy efficiency
  - Fifty percent are currently examining one or more of the following topics: (1) smart grid and advanced metering infrastructure (Smart Meters), (2) utility business model reform, (3) regulatory reform, (4) utility rate reform, (5) energy storage, (6) microgrids, and (7) demand response[59]
  - South Carolina established a 36% carbon reduction goal from 2012 emissions[60]
  - South Carolina target of 2% but significant renewables investment underway[61]
  - Stakeholder interest in expanding utility and customer-owned solar in South Carolina
  - South Carolina Technology and Aviation Center is developing a business park in Greenville dedicated to providing a collaborative environment for companies to develop smart city technologies[62]
    - More than 100 new smart technology companies expected to be part of the park

Growth in Reporting Related to Greenhouse Gas Emissions (1992-2017)



Source: World Business Council for Sustainable Development[63]

Contracted Capacity of Corporate Power Purchase Agreements, Green Tariffs, and Outright Project Ownership



Source: Business Renewables Center[64]

IV. IMPACT OF WEATHER EVENTS

What is happening?

- "With climate change and sea-level rise, we'll all be dealing with the issues of water, drainage and extreme weather. That means setting the kind of zoning, planning and building requirements that anticipate living with water."

  - Charleston Mayor John Tecklenburg (9/28/2018)[65]

- South Carolina has faced major weather events in each of the last four years, with Hurricanes Matthew (2016) and Florence (2018) illustrating the magnitude of the challenge the grid faces today from weather
  - Approximately 830,000 people in South Carolina without power during Hurricane Matthew[66]
  - Approximately 1.8 million total Duke Energy customer outages restored across the Carolinas during Hurricane Florence, 178,000 of which were Duke Energy customers in South Carolina[67]
  - Marion and Horry County residents, not yet recovered from Hurricane Matthew, devastated by Hurricane Florence two years later[68]
- Severe ice storms have historically impacted South Carolina's power lines[69]

Hurricane Florence Impacts (2018)

Nichols, SC
Source: The State[70]

Hurricane Irma Impacts (2017)

Source: The Post and Courier[71]

Hurricane Matthew Impacts (2016)

Nichols, SC
Source: CNN[72]

Ice Storm Impacts on Overhead Lines (2015)

Source: Greenville News[73]

IV. IMPACT OF WEATHER EVENTS

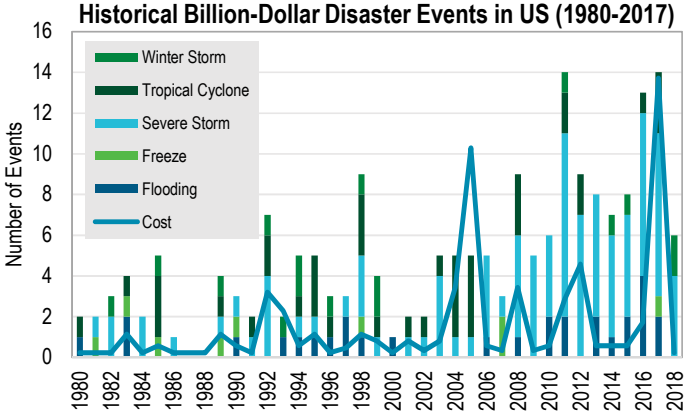
What is happening?

- South Carolina experienced over 170 bulk electric system outages related to weather events (2008-2017) and is part of a larger region that sees the most major storms[74]
- The number of customers impacted by weather events is increasing due to population growth in regions most affected by weather
- The average number of interruptions that a Duke customer would experience (SAIFI) increased by 19% (SC DEC) and 2% (SC DEP) and the average outage duration for each Duke customer served (SAIDI) increased by 28% (SC DEC) and 51% (SC DEP) (2012-2017)[75]
- Number of major event days (MEDs) have increased by 2% per year over the past 25 years[76]
- Number of Duke Energy SC customer outage events increased by 10% since 2012[77]

Temporary Flood Mitigation at 6 Carolinas East Station

Source: Duke Energy[78]

Historical Billion-Dollar Disaster Events in US (1980-2017)



Note: Costs are adjusted for Consumer Price index (inflation)

Source: NOAA[79]

V. GRID IMPROVEMENT – NATIONAL VIEWS

What is happening?

- Grid improvement technology has advanced over the last decade, and has given utilities alternatives to traditional grid infrastructure options.
  - Grid improvement got a boost from $4 billion in Smart Grid Investment Grants under the American Recovery and Reinvestment Act of 2009 (the Stimulus Act) which, combined with industry spending, led to nearly $8 billion in related projects[80]
  - "Smart" grids are expected to increase the grids' efficiencies by 9% by 2030. This is equivalent to saving more than 400 billion kilowatt-hours each year[81]
  - Grid improvement deployments reduce peak demands by 13% to 24%[82]
  - Savings between $46 billion and $117 billion are expected over the next 20 years[83]
  - Smart meters are expected to save more than $150 billion/year by 2020 by reducing the cost of power interruptions by more than 75%[84]
- The global market for smart grid IT and analytics for software and services is expected to grow from approximately $12.8 billion in 2017 to more than $21.4 billion in 2026[85]

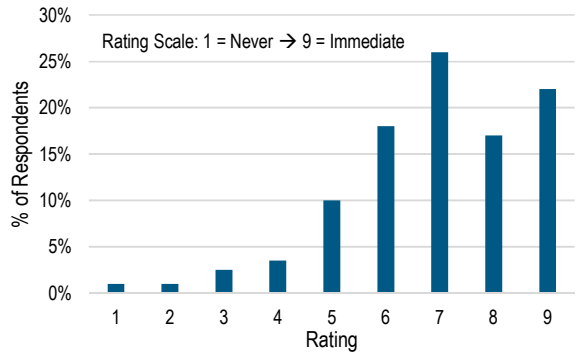
Rapidly Advancing Smart Grid Technologies

Intelligent Devices	Information Technology
• High speed communication networks (fixed and wireless) • Smart Meters • Distribution Automation including intelligent switches, capacitors, and remote fault identification	• Advanced Distribution Management Systems (ADMSs) • Integrated Volt/Volt-ampere reactive Control (IVVC) • Fault, location, isolation, and service restoration (FLISR) • Asset Management Systems (AMSs) • Customer Information Systems (CISs) • Demand Response Management Systems (DRMSs) • Distributed Energy Resources Management Systems (DERMSs) • Energy Management Systems (EMSs) • Geographic Information Systems (GISs) • Meter Data Management Systems (MDMSs) • Advanced Analytics (Asset, Grid Operation, Demand-side, Customer)

Source: Navigant[86]

"Pulse of Power" Survey of Readers

How soon should the power industry adapt to a clean, intelligent, mobile, and distributed grid?



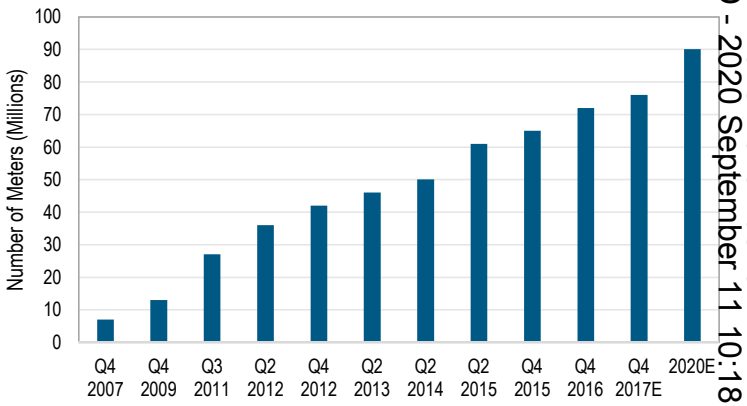
Source: Public Utilities Fortnightly[87]

V. GRID IMPROVEMENT – SMART METER DEPLOYMENT

What is happening?

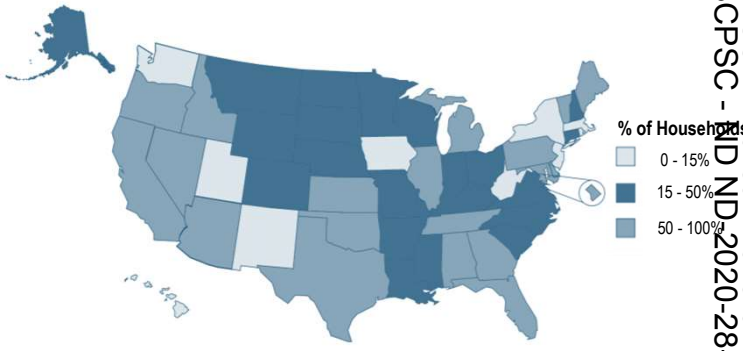
- Deployment of Smart Meters is an indicator of grid modernization adoption by utilities
  - Two-way Smart Meters allow utilities and customers to interact to support smart consumption applications using real-time or near real-time electricity data
  - Smart Meters support demand response and distributed generation, improve reliability, and provide information that consumers use to save money by managing their use of electricity
  - Smart Meter data provides utilities with detailed outage information in the event of a storm or other system disruption, helping utilities restore service to customers more quickly and reducing the overall length of electric system outages
- National Smart Meter installations are approaching 76 million and is projected to reach 90 million by 2020[88]
  - By the end of 2016, there were a total of 855,345 Smart Meters installed in South Carolina[89]
  - Currently, 620,868 Smart Meters (587,707 in South Carolina DEC and 33,161 in South Carolina DEP) are installed in South Carolina areas under Duke Energy's territory[90]

US Smart Meter Installations (2007-2020)



Source: The Edison Foundation[91]

Residential Smart Meter Adoption Rates by State (2016)



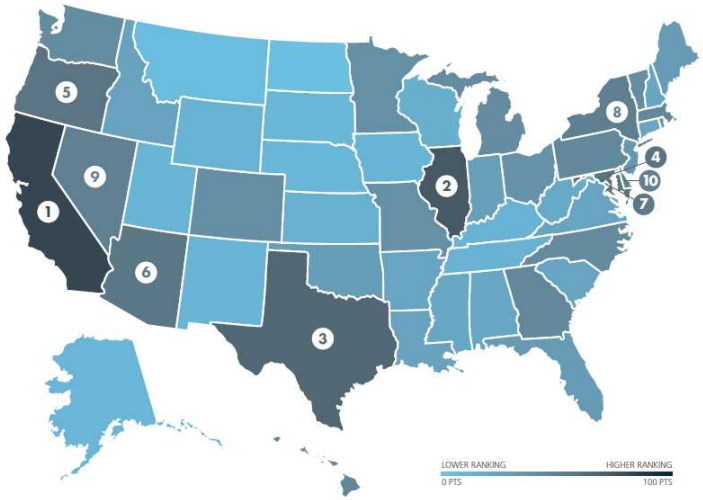
Source: The Edison Foundation[92]

V. GRID IMPROVEMENT – REGULATORY STATE POLICY ACTIONS

What is happening?

- The SC Energy Plan states that "if South Carolina is to participate in the innovation coming to fruition in the electric sector, (for example, solar panels, wind turbines, EVs, battery storage, and microgrids) then the state will require an advanced, integrated grid to manage and optimize the increasingly dynamic flow of electricity"[93]
- In Q1 2018, 37 US states and the District of Columbia took grid modernization actions involving regulations and legislature. Most of these actions involved Smart Meters, energy storage, and utility business model reforms[94]
- South Carolina was ranked 33rd on the GridWise Alliance's 2017 Grid Modernization Index, which evaluates the leading states using a three-part score based on state support, customer engagement, and grid operations[95]

Grid Modernization Index Across the US



Source: GridWise Alliance[96]

Sample of Targeted Cost Recovery Mechanisms for Grid Modernization Investment

State	Type of Investment
California	Research and technology development
Massachusetts	Grid modernization
Minnesota	Grid modernization
New Jersey	Hardening infrastructure modernization
Ohio	Grid modernization
Pennsylvania	Advanced metering

Source: Navigant[97]

V. GRID IMPROVEMENT – UTILITY BENCHMARKING

What is happening?

- Utilities are adopting grid technology to support increasing DER penetration
- There are varying types of grid modernization technology, many of which are listed in the table below

Benchmarking of Utility Grid Modernization

Smart Grid Investment	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7
DER Penetration*	5%	25%	32%	55%	4%	<1%	<1%
Smart Meters		●	○	N/A**	○	●	●
Demand Response	○	●	●	◐	◐		◐
Distribution Automation	●	◐	○	●		●	●
Substation Automation	◐	◐	○	◐	◐	●	●
Advanced Communications	●	◐	◐	◐	◐	●	○
Energy Storage	○	◐	◐	◐	○		◐
Electric Vehicle Charging	◐	◐	○	◐	○	○	◐
Volt VAR Optimization	○	○	○		○	◐	◐
Time-of-use Pricing		◐	○	N/A**	◐		●
DERMS/ADMS	○	○	○	○	○	○	○
Microgrids			◐	○			◐
Undergrounding of Circuits	◐		◐	●			◐
Recovery Mechanism	●	●	●	◐	●	●	●

Source: Navigant[98]

*As percentage of peak demand. Note that utilities may define DER resources somewhat differently.
**Utility 4 market structure does not allow them to deploy Smart Meters or TOU rates

● **Large Scale**: utility has deployed technology in majority of its jurisdiction, and has begun evaluating the impacts on its system.

◐ **Pilot/Small Scale**: utility has deployed technology in one to a few locations, and has not been implemented long enough to evaluate its impact.

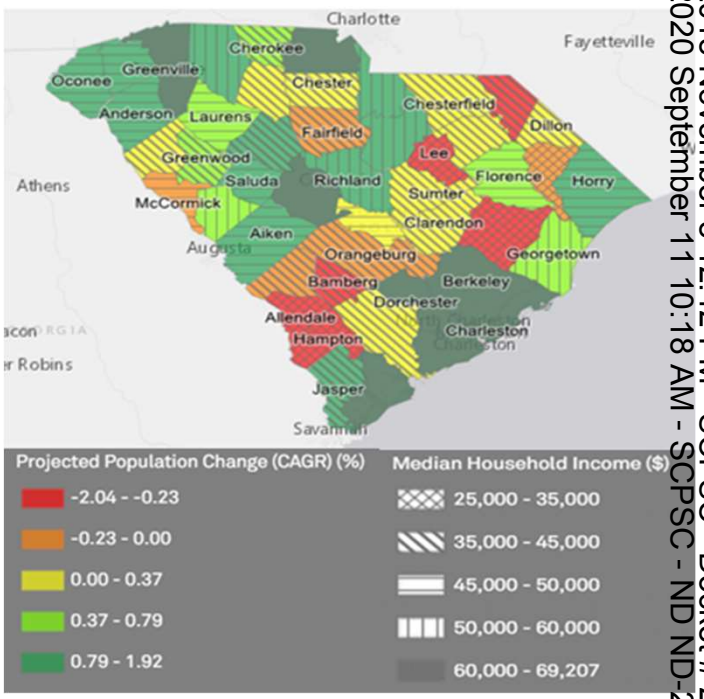
○ **Planned**: utility has not deployed the technology yet, but has plans for implementation in their most recent smart grid filing.

VI. CONCENTRATED POPULATION GROWTH

What is happening?

- People, wealth, and jobs continue to concentrate in urban and suburban areas
  - Movement is being driven by shifting demographics and changing lifestyle preferences
  - Many suburban areas getting an urban makeover with mixed-use development, thoughtful public spaces, transit options, and community-focused street-level development
  - Businesses, industry, and construction are following suit to take advantage of increased population density and connectivity
- South Carolina's population is expected to grow by ~8% (2018-2026)[99]
  - Greenville and Spartanburg counties ("Auto Corridor") accounted for 64% of Upstate's growth[100]
    - BMW currently hiring and training 1,000 additional workers[101]
    - Suppliers have announced $200 million in investment over the past 18 months[102]
  - Charlotte suburbs Fort Mill and Tega Cay experienced ~52% and ~33% growth, respectively[103]
  - Even outside of economic development efforts so prevalent in SC, a significant number of rural counties project stagnant or declining population
- Load is growing with population requiring new infrastructure
  - Load in downtown Spartanburg and Greenville growing 3%-5% per year[104]
  - There are challenges and costs siting new infrastructure in constrained areas

SC Projected Population and Income Demographics



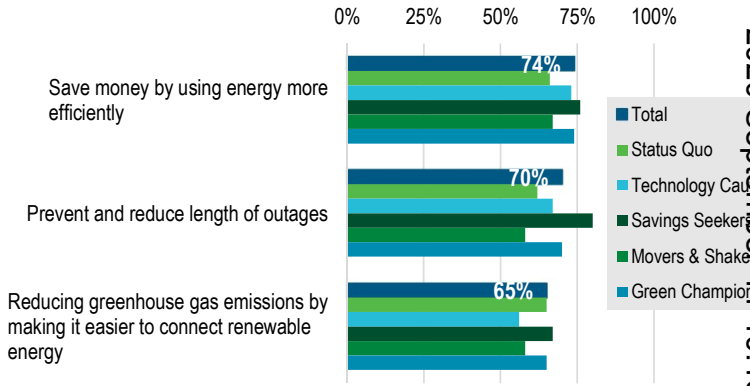
Source: S&P Global[105]

VII. CUSTOMER EXPECTATIONS

What is happening?

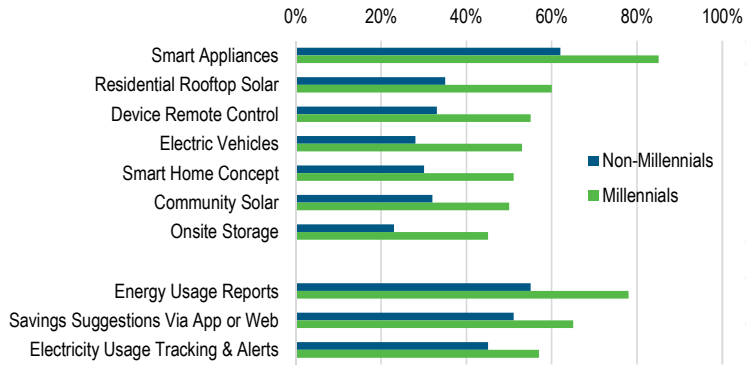
- Customers want to save money and reasonably reduce outages and greenhouse gas emissions[106]
  - Relative importance of these three may vary across customer personas, but they remain consistently the top factors
  - Customers want smart grid investments to reflect these needs
- To address these needs, customers are interested in new technology and increased control over their usage, including (1) smart appliances, (2) rooftop solar, and (3) device remote control[107]
- Millennials are far more interested in energy-related topics than non-millennials[108]
- Duke Energy's high growth business segments (advanced manufacturing, healthcare, data centers) requiring substantial mission-critical electrical infrastructure and cost-effective energy management services
- SC State Energy Plan recognizes that "meeting customer expectations for power and providing immediate restoration when an outage does occur require enhancements and improvements to South Carolina's electric infrastructure"[109]
- Percentage of Customers Experiencing Multiple Interruptions 6 or more times a year (CEMI-6) is projected to increase by 66% by 2028[110]

Factors customer perceive as important for utility supply



Note: These are the top 3 choices for all types of respondents
Source: Smart Energy Consumer Collaborative[111]

Interest in Energy-related Concepts

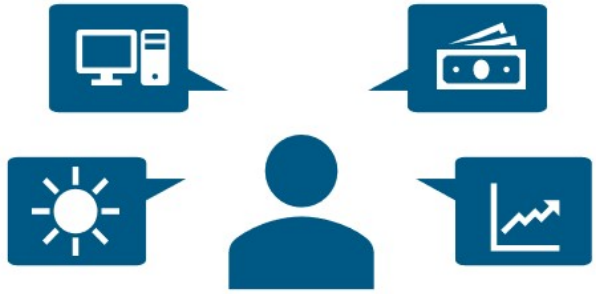


Source: Smart Energy Consumer Collaborative[112]

VII. CUSTOMER EXPECTATIONS

What is happening?

Today, in South Carolina:[113]



- Customers want their power to be on all the time as much as this is reasonably possible
- Customers want their power to be safe
- Customers do not want their power company to harm the environment
- Customers want their power to be as cheap as reasonably possible
- Customers want their interactions with the power company to be as easy and user-friendly as possible
- Customers want increases to their power bills to be minimal, infrequent, and predictable as possible
- Customers want to be informed of problems and issues in advance where possible and want to be updated with status reports as problems are being resolved
- Customers know and accept that there are things beyond our control that will cause power outages no matter what actions we take to prevent them
- Customers are more accepting of power outages when they know what caused the outage and how long it will take to restore power
- The frequency of outages and power quality issues are generally more important to customers than the duration of outages and events
- Most non-residential customers have built the effects of outages and power quality issues in to their business costs and are not willing to pay significantly more to prevent them
- Only some highly power-dependent customers (mostly complex businesses) have taken or are willing to take extraordinary measures to ensure a virtually uninterrupted supply of power

SOUTH CAROLINA GRID IMPROVEMENT PLAN

APPENDIX

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SOUTH CAROLINA GRID IMPROVEMENT PLAN

IMPLICATIONS

IMPLICATIONS TO OUR CUSTOMERS FROM THE MEGATRENDS

Our customers are impacted by the megatrends, and, under business as usual (BAU), our customers' expectations will not be met and we will miss the opportunity to optimally use advanced technology.

I Increased costs

II Reduced reliability and resiliency

III Reduced ability to manage and integrate distributed energy resources (DER)

IV Reduced ability to meet customer expectations and commitments

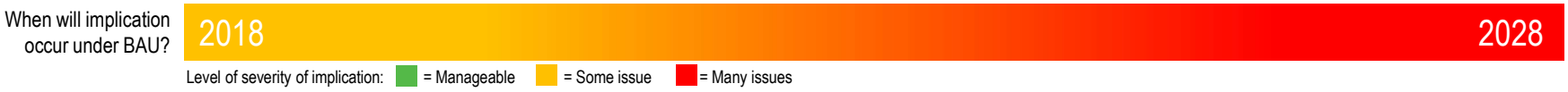
V Reduced economic competitiveness for South Carolina

VI Increased geographic and demographic disparity

I. INCREASED COSTS

Under business as usual, costs to customers may increase as compared to emerging alternatives.

Megatrend	BAU Threat	Opportunity
Concentrated Growth	Costs to build BAU infrastructure in urban and suburban areas with concentrated growth are increasing, and do not provide enhanced capabilities to meet expected future grid needs. These costs will be borne by all customers, including those in rural areas that are unaffected.	Advanced system controls, intelligence, planning, and automation would improve overall system efficiency using existing and new assets and thus lower costs for all customers from what they would otherwise be. Additionally, grid capacity needs and the need for two-way power flow can be addressed proactively.
Technology Advancements – Renewables and DER	Because DER is becoming more cost competitive, customers are installing DER and EVs, which, in turn, require improvements to the grid beyond BAU which increases costs if not done in a proactive and planned manner. The reduced load from DER can also lead to higher bills.	Advanced tools and technologies will enable greater application of DER on the grid. Effectively planning for and optimizing the installation of DER on the grid will lower costs for all customers from what they would otherwise be while maintaining safe and reliable operation of the grid.
Grid modernization	"Like for like" replacement of technology will not lower costs beyond what it is today because capital and operating cost will be unchanged. Further, as the grid is impacted by other trends, existing grid technology may require more rapid replacement, thus increasing costs.	Using advanced grid technologies, system and operational efficiency are increased which lower costs to customers from what they would otherwise be.
Customer Expectations	Customers want to save money and under business as usual, costs will not decline and may go up. As the grid increasingly interconnects DER, interconnection costs of an individual project increase, making it cost prohibitive for customers to have more DER options.	With appropriate grid capabilities, such as ability to manage two-way power flow and intermittent resources, customers will have options that help them manage their costs better, including DER and usage management tools.
Environmental Commitments	Corporations and governments will not be able to meet their environmental goals and commitments if it becomes cost prohibitive to do so. And, in the case where interconnection costs are not incurred, such as with EV, costs to meet these goals and commitments are borne by all customers.	Advanced tools and technologies will enable greater application of DER on the grid, including renewable energy resources. Effectively planning for and optimizing the installation of DER on the grid will lower costs for all customers from what they would otherwise be while maintaining safe and reliable operation of the grid.
Impact of Weather Events	Absent resiliency and reliability improvements, customers will see increased costs from outages as they increase in number and severity. These costs include those incurred by the utility and by customers.	Proactively hardening the system and building advanced monitoring, smart control and grid intelligence can reduce the occurrence and duration of outages, saving customers money compared to business as usual.
Threats to Grid Infrastructure	Absent adequate protection against modern threats, costs to customers will increase due to increased attacks. These costs include those incurred by the utility and by customers.	By building cyber and physical protections that go beyond current compliance requirements to anticipate threats of the future, occurrence and duration of outages can be reduced saving customers money compared to business as usual.



II. REDUCED RELIABILITY AND RESILIENCY

Under business as usual, reliability will not improve and may decrease.

Megatrend	BAU Threat	Opportunity
Concentrated Growth	In concentrated growth areas, reliability will decrease if improvements to the grid don't keep pace with concentrated load increases and DER penetration. Reliability will decrease in rural areas where flat load growth does not support traditional grid strategies.	Advanced system controls, intelligence, planning, and automation can improve overall system efficiency using existing and new assets and thus can improve reliability for all customers. .Additionally, grid capacity needs and the need for two-way power flow can be addressed proactively, which can improve reliability.
Technology Advancements – Renewables and DER	Because DER is becoming more cost competitive, customers are installing DER and EV at an increasing rate, which may decrease reliability due to voltage fluctuation and capacity limitations on the distribution system.	Using rapidly advancing technology and systems, the utility can provide active monitoring and control power flow and improved voltage fluctuation issues using "grid-edge" decision making. Non-traditional applications are also an opportunity to improve reliability.
Grid modernization	"Like for like" replacement of existing grid infrastructure will not improve reliability beyond what it is today because functionality will not have improved. In particular, the number of customers that experience multiple interruption per year will increase (CEMI-6).	Rapidly advancing grid technologies are available to improve grid reliability, including improving visibility to a more granular level of where outages are occurring and enable grid-edge decision making and control.
Customer Expectations	Customer satisfaction will decrease with increased outages, and reduced power quality, as customers are inconvenienced or unable to work. These outages may be caused from voltage or power flow issues from DER, traditional infrastructure, or major events such as weather or cyber attack	Customers expectations of reduced outages (either short- or long-term) and better power quality would be addressed with the use of rapidly advancing grid technology and systems.
Environmental Commitments	Customers with environmental commitments will interconnect DER which could cause voltage and power flow issues on the grid resulting in reduced reliability. Conversely, if DER is curtailed to address the reliability issues, customers will be prevented from meeting their commitments.	Using advanced grid technologies and systems helps customers meet their environmental commitments without sacrificing reliability or resiliency.
Impact of Weather Events	The BAU approach of reacting to damage when storms occur will not improve resiliency. In particular, in concentrated areas, when storms damage equipment, it affects more customers.	Using advanced grid technologies and systems will reduce frequency of short-term outages and reduce time to recover from major storm-induced outages. Undergrounding or hardening the most outage prone lines reduces costs and major event duration for all customers from what they would otherwise be.
Threats to Grid Infrastructure	Cyber and physical threats to grid infrastructure are increasing rapidly. Failure to keep pace with these threats will result in compromised reliability and resiliency of the electric grid.	Aggressive development and implementation of advanced system protections and protocols will help the electric grid remain protected from the ever increasing number and variety of threats it faces every day. Also, in the event that a threat is successful, these measures will help minimize damage/disruption that could impact customers.

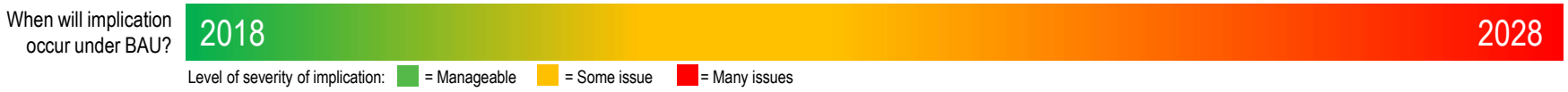
When will implication occur under BAU? 2018 → 2028

Level of severity of implication: = Manageable = Some issue = Many issues

III. REDUCED ABILITY TO MANAGE AND INTEGRATE DER

Business as usual limits the ability to manage and integrate DER, resulting in the need to curtail or issue moratoriums on customer-owned interconnection.

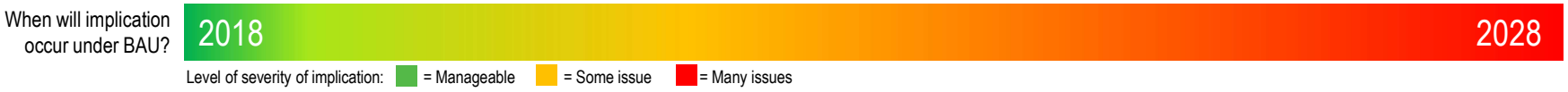
Megatrend	BAU Threat	Opportunity
Concentrated Growth	The existing constrained grid in urban areas limits the ability to interconnect DER for customers who are interested in renewable energy, storage and electric vehicles.	Advanced tools and technologies that enable two-way power flows will allow for increased application of DER on the grid. Effectively planning for and optimizing the installation of DER's on the grid will lower costs for all customers beyond what they would otherwise be while maintaining safe and reliable operation of the grid.
Technology Advancements – Renewables and DER	As more DER is connected to the grid, hosting capacity available for additional DER diminishes, causing customer interconnection costs to increase for future installations.	If the grid is able to handle two-way power flow by building capacity and using advanced monitoring and automation to manage DER, then DER can become a "tool in the toolbox" for grid operators.
Grid modernization	Current technology on the grid does not enable two-way power flow or voltage and power flow optimization needed to handle customer-sited, intermittent generation. This limits the ability for the grid to handle increasing capacity of DER.	With the use of advanced grid technologies (e.g. microprocessor based equipment), the grid could become a platform to connect and proactively use customer DER.
Customer Expectations	Customer satisfaction will decrease if customers are not given the option to connect DER, particularly renewables or EVs. If DER is not integrated properly, voltage fluctuations will cause DER to be curtailed.	If DER could be integrated, customers will have more energy options and be able to meet their individual needs such as to reduce greenhouse gases and reduce costs from what they would otherwise be.
Environmental Commitments	If customers, particularly corporations and governments, cannot interconnect renewable DER they will not meet their environmental goals.	By allowing customers to interconnect renewable generation, South Carolina will continue to be attractive to businesses with environmental commitments—this includes fast-growing sectors such as data centers, healthcare, and advanced manufacturing.
Impact of Weather Events	Grid-connected microgrids and other DER options for resiliency would not be able to be interconnected and used during severe weather events.	Customers will be able to leverage customer-owned resources in outages to improve resiliency by providing power in an outage at a local level.
Threats to Grid Infrastructure	Without proper protections, new "points of entry" that pose new cyber attack threat points, i.e. hacking a third-party resource, could impact the grid.	Duke Energy can work proactively with customers to build in protections upfront and over time as needs evolve.



IV. REDUCED ABILITY TO MEET CUSTOMER EXPECTATIONS AND COMMITMENTS

Business as usual will limit customer options, resulting in higher costs and lower reliability.

Megatrend	BAU Threat	Opportunity
Concentrated Growth	As the demographics of customers in urban and suburban load growth areas evolve they place a higher priority on uninterrupted and personalized energy service. Strained traditional systems in these areas will not be able to meet customer expectations.	Advanced system controls, intelligence, planning, and automation would improve overall system efficiency using existing and new assets and thus improve reliability for all customers. Building capacity for two-way power flow enables options and grid resiliency.
Technology Advancements – Renewables and DER	Under business as usual costs of customer interconnection will increase and curtailment and/or moratoriums will eventually be required which will not meet customer expectations for renewables and DER.	Advanced technologies such as advanced monitoring and controls and solutions that increase hosting capacity will reduce need for curtailment or moratoriums and decrease the cost of interconnection from what they would otherwise be.
Grid modernization	"Like for like" replacement of technology will not lower costs or improve reliability beyond what it is today because capabilities will be unchanged. Further, lack of visibility and control to customer-sited assets and outages will increase cost and reduce reliability.	Distribution automation, grid intelligence and other advanced technologies will minimize outages, accelerate power restoration, and open the opportunity to use DER.
Customer Expectations	Customers will be unhappy if expectations for affordability, reliability, and options are not met.	Access to new capabilities and offerings, as enabled by enhanced grid capabilities, enable customers to meet their expectations, encourage their participation in energy decisions and gives them more control over their energy use.
Environmental Commitments	The grid will increasingly have less ability to integrate DER and renewables which will cause customers to miss meeting their environmental commitments.	With enhanced grid capabilities, such as increased hosting capacity and the ability to integrate two-way power flow and intermittent resources (such as renewables), customers can meet their commitments with DER including solar, storage and EVs.
Impact of Weather Events	Absent resiliency and reliability improvements, customers will see increased costs and outages as storms and major weather events increase in number and severity. Increasing frequency of outages and increased costs lead to lower customer satisfaction.	By proactively hardening the system, undergrounding or hardening the most outage prone lines, and building advanced monitoring, control and grid intelligence, occurrence and duration of outages and associated costs can be reduced from what they would otherwise be.
Threats to Grid Infrastructure	Absent adequate protection against modern threats, customers will see increased costs and outages due to increased attacks. Increasing frequency of outages and increased costs lead to lower customer satisfaction.	By building cyber and physical protections that go beyond current compliance requirements to anticipate threats of the future, customers will be better protected from disruptions and costs of attack.



V. REDUCED ECONOMIC COMPETITIVENESS FOR SOUTH CAROLINA

DUKE ENERGY

Business as usual makes South Carolina less attractive for businesses and residents.

Megatrend	BAU Threat	Opportunity
Concentrated Growth	Growth will not be absorbed cost-effectively, thus increasing costs to all customers which drives South Carolina to be a less attractive place to live or do business. Additionally, businesses will be deterred from locating in urban areas (where employees are located) due to reliability issues.	Advanced grid technologies and grid capacity deployed in concentrated growth areas and throughout the system will help to maintain affordability across all customers and encourage business development and relocation to the State.
Technology Advancements – Renewables and DER	Due to the inability of the grid to handle increasing amounts of DER, options will be limited for businesses to deploy renewables and/or DER which will make the State less attractive for businesses that desire these options.	Advanced technologies such as advanced monitoring and controls and solutions that increase hosting capacity will allow more DER and renewables making it an attractive market for certain companies.
Grid modernization	Businesses will not be attracted to do business in South Carolina if the electric grid is not reliable or energy costs are less affordable due to existing equipment and operations. Further, prospective businesses may perceive South Carolina as not embracing rapidly advancing technologies.	A more resilient, reliable and intelligent grid will represent a modern, competitive energy system to current and prospective employers and their employees.
Customer Expectations	Customer satisfaction will decrease if expectations of affordability, reliability and options are not met, which could lead to residents and businesses choosing not to locate in the State.	Programs to protect, modernize and optimize the grid will provide reliable operation and offer customers the options they seek.
Environmental Commitments	The inability to utilize DER to meet environmental goals could inhibit commercial and industrial growth in South Carolina, particularly from large corporations with high renewable energy goals and environmental commitments.	Advanced grid technologies that increase hosting capacity and help to manage intermittency of renewable energy will make it possible for customers to pursue their environmental and sustainability commitments and be interested in South Carolina.
Impact of Weather Events	Absent resiliency and reliability improvements, customers will see increased costs and outages as storms and major weather events increase in number and severity resulting in decreased business and consumer confidence in the ability to stay open during storms.	By proactively hardening the system; undergrounding or hardening the most outage prone lines; and building advanced monitoring, control and grid intelligence; the occurrence and duration of outages and associated costs can be reduced helping customers be confident they can do business in an areas subject to storms.
Threats to Grid Infrastructure	Absent adequate protection against modern threats, customers will see increased costs and potential outages due to increased attacks resulting in decreased business and consumer confidence.	By building cyber and physical protections that go beyond current compliance requirements to anticipate threats of the future, customers will be better protected from disruptions and costs of attack helping customers be confident they can do business despite threats.

When will implication occur under BAU?

Level of severity of implication: = Manageable = Some issue = Many issues

VI. INCREASED GEOGRAPHIC AND DEMOGRAPHIC DISPARITY

Business as usual will not adequately meet the needs of rural customers in the future.

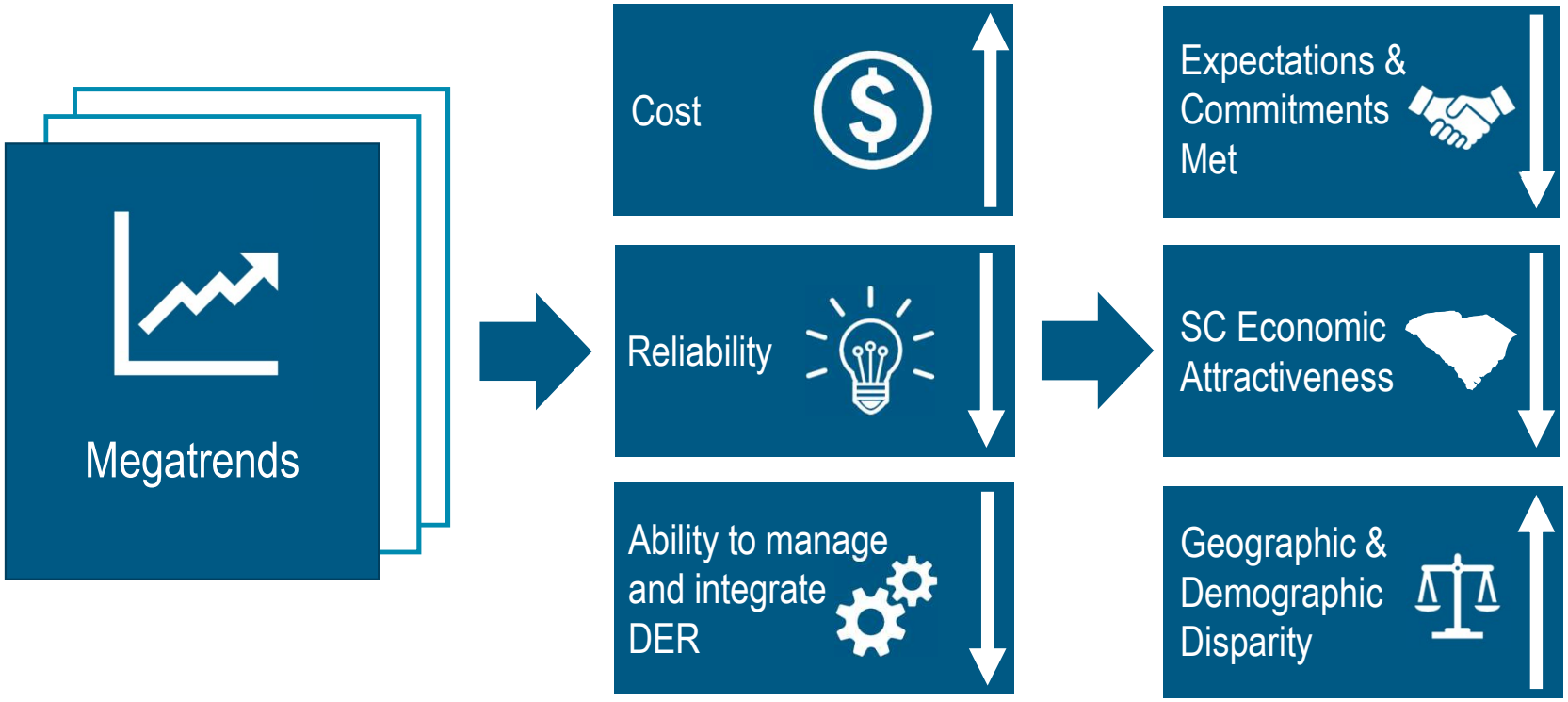
Megatrend	BAU Threat	Opportunity
Concentrated Growth	Capital demands to meet system expansion in high growth areas can undermine investment in rural areas of the state causing disparity between customer demographics and geography.	Advanced system controls, intelligence, planning, and automation would improve overall system efficiency using existing and new assets and thus improve reliability for all customers. Building grid capacity and the ability for two-way power flow enables options and grid resiliency.
Technology Advancements – Renewables and DER	Growth and demographic trends suggest that DER will predominate in urban and suburban centers that have an increasingly younger and higher-wealth demographic, leading to a lesser participation from and cost shifting to lower income or rural customers.	Advanced tools and technologies will enable greater application of DER on the grid. Effectively planning for and optimizing the installation of DER on the grid will lower costs for all customers from what they would otherwise be while maintaining safe and reliable operation of the grid.
Grid modernization	Under business as usual, capital allocated for traditional system improvements necessarily goes to areas where there is highest load and customer count. As a result, rural areas see less timely improvements to the grid under legacy practice using traditional technology.	By optimally implementing new capabilities that reduce costs of improvements and operations in constrained urban areas, additional focus can be given to improvements in rural areas. In addition, grid automation will enhance ability to serve remote areas of the system.
Customer Expectations	Business as usual will not allow all customer classes to equally address their expectations for affordability, reliability and options.	Additional capabilities and programs can be used to proactively address the needs of all customer classes and open new opportunities for all customers.
Environmental Commitments	Under business as usual, only certain customers and businesses will be able to deploy DER or renewables needed to meet their commitments.	Advanced grid technologies that increase hosting capacity and help to manage intermittency of renewable energy will make it possible for all customer to have access to more DER or renewables.
Impact of Weather Events	Absent resiliency and reliability improvements, customers will see increased costs and outages as storms and major weather events increase. This is particularly challenging in rural areas where cost and times for repairs are higher due to longer radials and distance for crews to cover.	By proactively hardening the system, undergrounding or hardening the most outage prone lines, and building advanced monitoring, control and grid intelligence, the occurrence and duration of outages and associated costs can be reduced, particularly in hard-hit rural areas.
Threats to Grid Infrastructure	Absent adequate protection against modern threats, customers may see increased costs and outages due to increased attacks. In particularly, physical attacks will be more detrimental in radial systems, particularly in rural areas, due to singular failure points.	By building cyber and physical protections that go beyond current compliance requirements to anticipate threats of the future, customers will be better protected from disruptions and costs of attack in rural areas.

When will implication occur under BAU? 2018 — 2028

Level of severity of implication: = Manageable = Some issue = Many issues

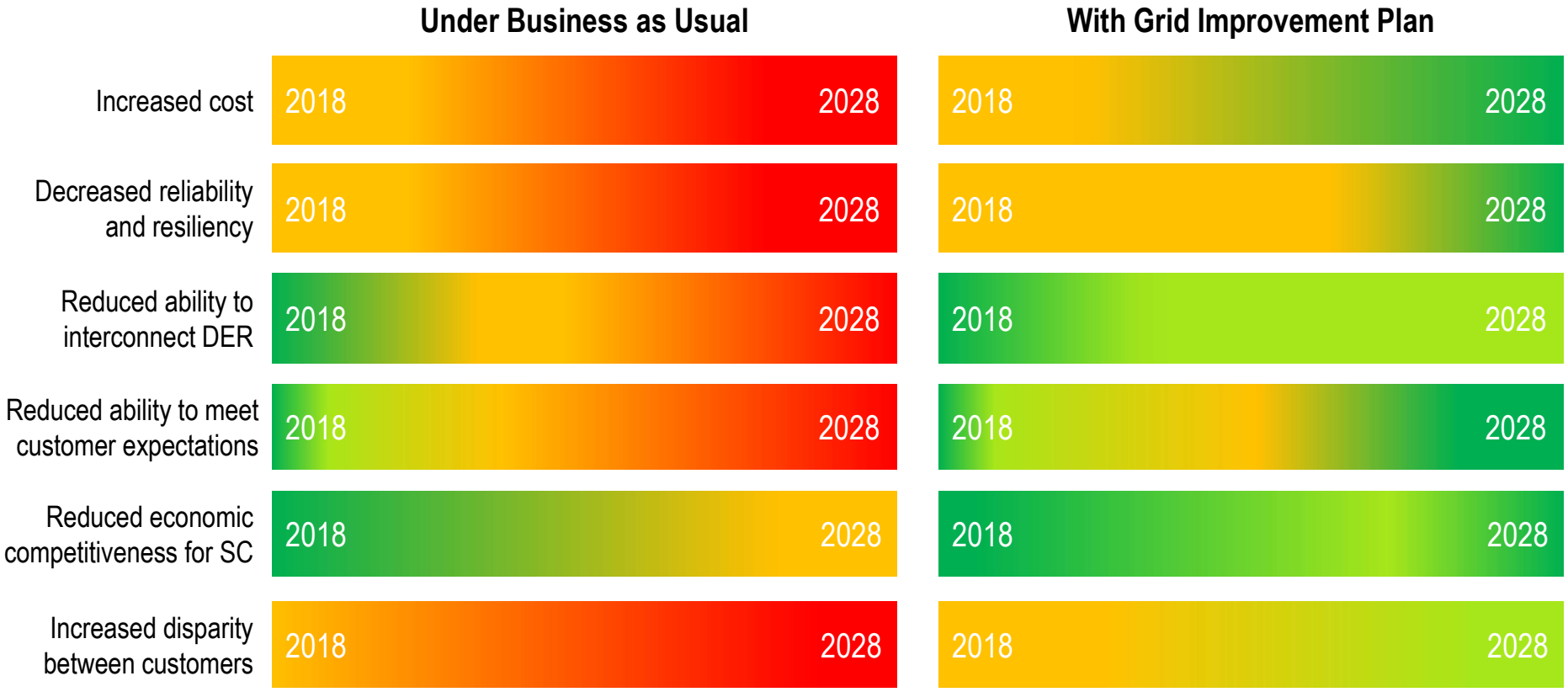
IMPLICATIONS OF MEGATRENDS

In summary, evolving megatrends will have implications on our customers and the State.



IMPACT OF GRID IMPROVEMENT PLAN ON IMPLICATIONS

Over time, the Grid Improvement Plan will reduce the degree of severity of the implications experienced under business as usual.



SOUTH CAROLINA GRID IMPROVEMENT PLAN

PROGRAM SUMMARIES

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PROGRAM: INTEGRATED VOLT/VAR CONTROL (IVVC)

The IVVC program establishes control of distribution equipment in substations and on distribution lines to optimize delivery voltages to customers and power factors on the distribution grid.

DESCRIPTION

IVVC allows the distribution system to optimize voltage and reactive power needs. The program employs remotely operated substation and distribution line devices such as voltage regulators and capacitors. The settings for thousands of these controllable field devices are optimized and dispatched via a distribution management system.

IVVC capabilities enable a grid operator to lower voltage as a way of reducing peak demand (peak shaving), thereby reducing the need to generate or purchase additional power at peak prices, or protecting the system from exceeding its load limitations. The current DEP **Distribution System Demand Response (DSDR)** program uses the peak shaving mode of IVVC to support emergency load reduction.

Another operational mode enabled by IVVC capabilities on the distribution system is **Conservation Voltage Reduction (CVR)**. CVR uses IVVC during periods of more typical electricity demand to reduce overall energy consumption and system losses.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: INTEGRATED VOLT/VAR CONTROL (IVVC)

MORE ABOUT THE PROGRAM

The Distribution Management System (DMS), which manages the dispatch of IVVC functionality, can be designed to manage distribution circuits such that any impacts to customers with large motors sensitive to voltage control can be reduced. To maximize operational flexibility and value, the IVVC system can also have peak shaving capability and emergency modes of operation. Advanced DMS software upgrades will enable IVVC to operate in various modes to provide further customer benefit in the future.

DSDR to CVR in DEP

In 2014, Duke Energy implemented DSDR in DEP, achieving peak shaving voltage reduction of approximately 3.6% across the DEP distribution system. The DMS in DEP is capable of optimized modes (i.e., DSDR) or non-optimized (i.e., emergency) modes. When in emergency mode, the system can quickly provide a temporary voltage reduction capability of up to 5.0%.

DEP's initial implementation of DSDR also included a significant amount of circuit conditioning to optimize the system for DSDR mode (i.e., the installation of voltage regulating devices and capacitors, balancing of load on distribution circuits, and reconductoring of some distribution lines to larger wire sizes).

Because the substation, distribution, telecommunications, and IT infrastructure were put in place as part of the original DSDR implementation, this sub-program focuses on the deployment of the few additional device installations as well as the DMS upgrades required to support various operational modes, including the current DSDR mode and CVR mode, as well as Self Optimizing Grid and other distribution automation capabilities.

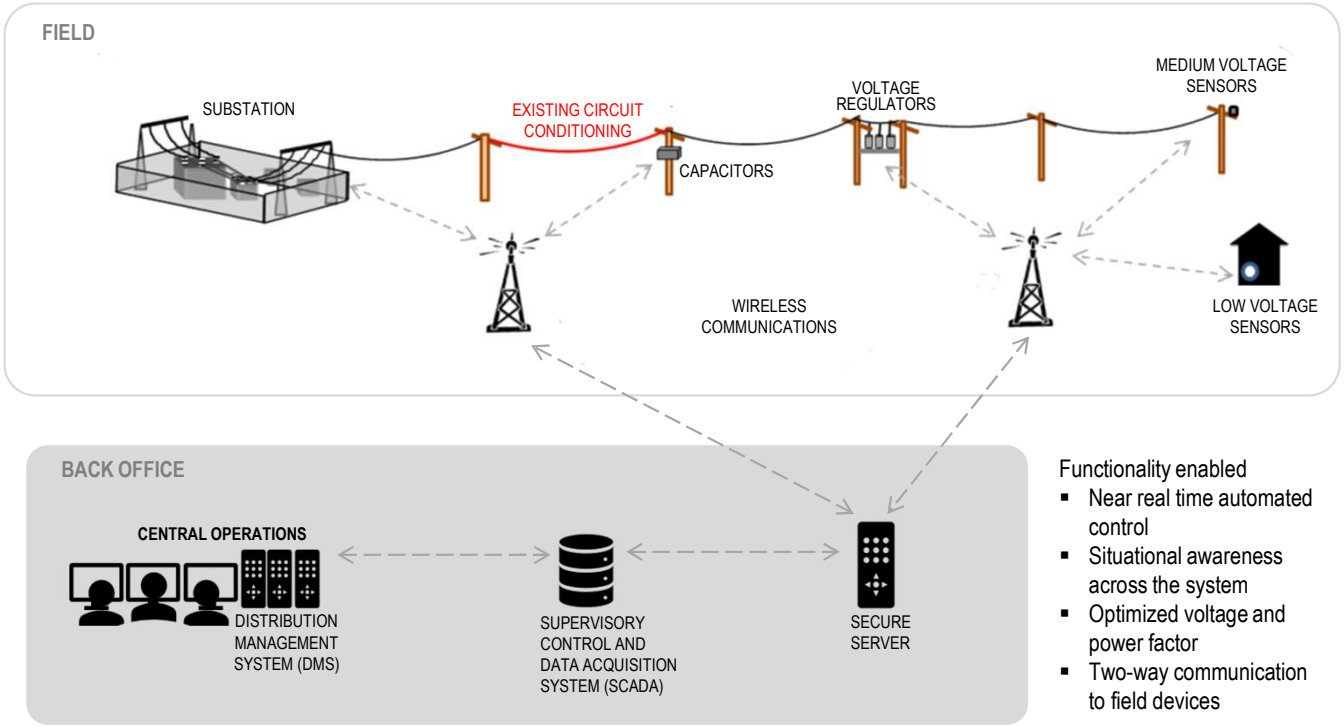
Through this sub-program, Duke Energy will enable 2% voltage reduction for energy conservation (an average of roughly 1.4% load reduction).

IVVC Project in DEC

The DEC IVVC pre-scale deployment project used real-time field conditions on a small scale to demonstrate the use of IVVC on the DEC system, and validate benefits in advance of its full-scale rollout. The small-scale demonstration validated voltage reductions of approximately 2% are possible with appropriate transmission and distribution system upgrades.

The DEC IVVC project will install communications and voltage control infrastructure at substations and associated distribution lines. The project will also leverage overlaps with efforts like Self Optimized Grid projects that deploy some of the infrastructure and capabilities necessary to enable IVVC.

PROGRAM: INTEGRATED VOLT/VAR CONTROL (IVVC)



Functionality enabled

- Near real time automated control
- Situational awareness across the system
- Optimized voltage and power factor
- Two-way communication to field devices

SMART CAPACITOR BANK

PROGRAM: SELF-OPTIMIZING GRID (SOG)

The self-optimizing grid program, also known as the smart-thinking grid, redesigns key portions of the distribution system and transforms it into a dynamic self-healing network.

DESCRIPTION

The current grid has limited ability to reroute or rapidly restore power and limited ability to optimize for the growing penetrations of distributed energy resources (DER). The SOG program is established to address both of these issues.

The SOG program consists of three (3) major components: grid capacity, grid connectivity, and automation and intelligence. The SOG program redesigns key portions of the distribution system and transforms it into a dynamic smart-thinking, self-healing grid. The grid will have the ability to automatically reroute power around trouble areas, like a tree on a power line, to quickly restore power to the maximum number of customers and rapidly dispatch line crews directly to the source of the outage. Self-healing technologies can reduce outage impacts by as much as 75 percent.

The **SOG Capacity projects** focus on expanding substation and distribution line capacity to allow for two-way power flow. **SOG Connectivity projects** create tie points between circuits. **SOG Automation projects** provide intelligence and control for the Self Optimizing Grid. Automation projects enable the grid to dynamically reconfigure around trouble and better mange local DER.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ IMPROVE RELIABILITY
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: SELF-OPTIMIZING GRID (SOG)

MORE ABOUT THE PROGRAM

The SOG program, also known as the smart-thinking or self-healing gird, implements distribution system design guidelines that improve grid reliability and resiliency. SOG circuits will have automated switches to divide the circuit into switchable segments. Each segment is designed to consist of approximately 400 customers, three miles in circuit segment length, or serve 2MW of peak load. This design ensures that any issues on the system can be isolated, and customer impacts are limited. The long term vision is to serve 80% of customers by the Self-Optimizing Grid.

Advanced Distribution Management System (ADMS)

The ADMS subprogram is an enterprise-wide program to deploy a common distribution management system. Consolidating to a single platform for DMS and SCADA systems enables operational efficiency and the ability to integrate future solutions needed as demands on the distribution system evolve. The three main projects are: (1) **SCADA upgrade project** which upgrades the supervisory control and data acquisition system; (2) **DMS common platform project** which deploys a common version of DMS across DEC and DEP; and (3) **Closed loop FLISR project** which deploys DMS functionality that minimizes the area impacted by the resulting outage.

SOG Segmentation & Automation

This subprogram focuses on segmenting circuits in accordance with SOG design guidelines (segments should serve approximately 400 customers, are three miles in length or serve 2 MW of peak load) and equipping those segments with automated switching devices. The purpose is to limit the exposure of customers to power outages associated with faults on a line (e.g., a tree falling or vehicle-power pole collision). This is accomplished by sectionalizing a circuit by adding and/or re-configuring a number of protective devices on tap lines.

Circuit Capacity and Connectivity

This subprogram focuses on upgrading selected circuit feeders and tying them together to meet the SOG design philosophy. The circuit capacity activities involve upgrading the feeder conductor and voltage control devices to enable a circuit to carry its own customer load as well as portions of adjacent circuit customer load, as needed.

Substation Bank Capacity

This subprogram focuses on upgrading selected substations to meet the SOG design philosophy. The substation bank capacity activities involve upgrading existing substation transformers and other associated equipment to allow for a substation to service its normal customer load as well as any additional load it may pick up during a SOG isolation/reconfiguration event.

PROGRAM: POWER ELECTRONICS FOR VOLT/VAR

The Power Electronics program integrates protection and control technology, helps reduce power quality issues associated with high DER penetration, and ultimately improves reliability to customers.

DESCRIPTION

As the adoption of distributed energy resources (DER) (e.g., customer-owned solar and energy storage) reaches critical levels and microgrid technology matures, protective device technology must also advance to appropriately detect and respond to rapid voltage and power fluctuations that often accompany non-dispatchable resources such as solar.

As clouds move across the daytime sky and momentarily block sunlight from reaching solar panels, solar generation immediately ceases. As sunlight peaks through openings in the cloud cover, the solar panels begin generating, creating power spikes and voltage instability on the circuit. These intermittent power impacts occur and then change at rapid rates (in some cases sub-second) and frequently faster than the legacy electro-mechanical voltage management equipment like regulators and capacitors can handle.

Integrating advanced solid-state technologies like power electronics (i.e., static VAR compensators and other solid-state voltage support equipment), better equips the distribution system to manage power quality issues associated with increasing DER penetration.

The program is still in its early stages and current plans are small pre-scale deployments to validate capabilities and benefits.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY

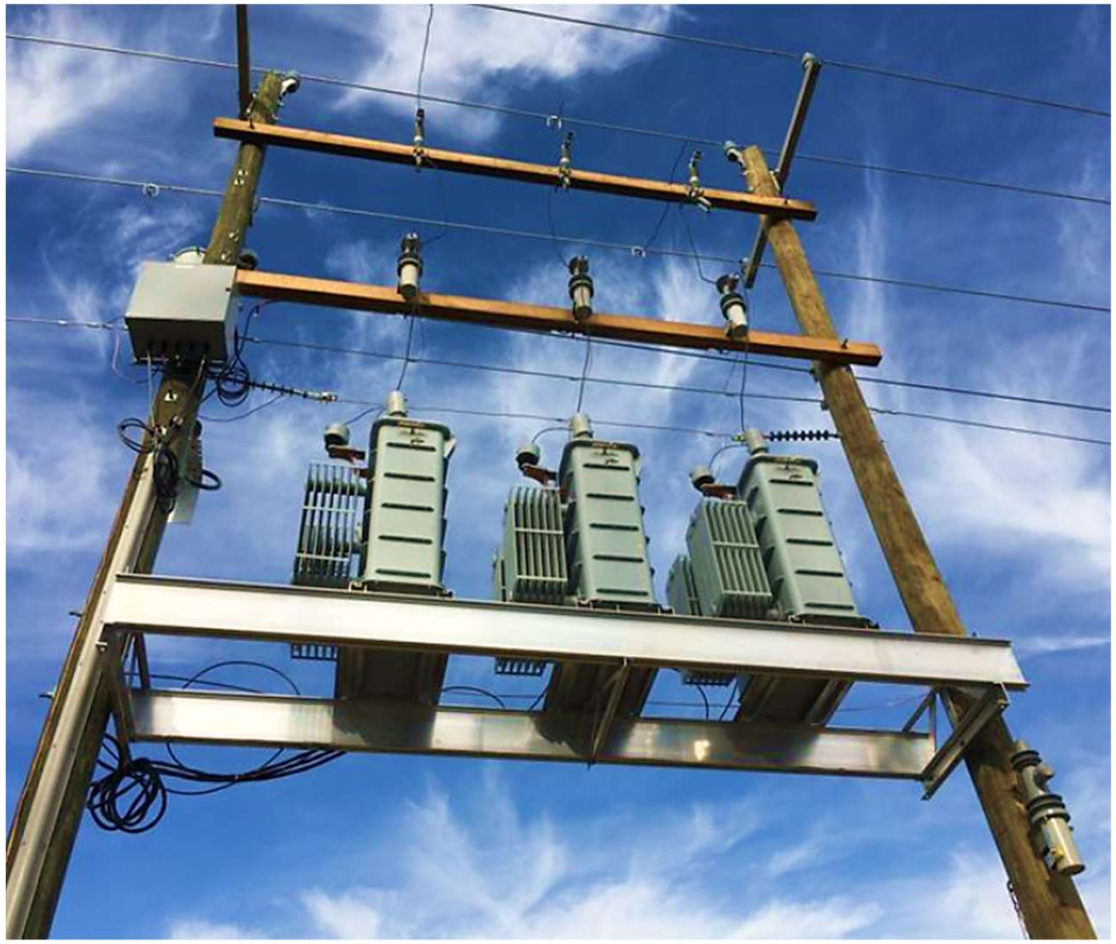
VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: POWER ELECTRONICS FOR VOLT/VAR



FIRST INSTALLATION OF MINIDVAR IN DEP TERRITORY

COST-EFFECTIVE UPGRADE FOR FEEDERS WITH HIGH SOLAR PV OR DG GROWTH

PROGRAM: DISTRIBUTION SYSTEM AUTOMATION (DA)

The DA program improves how the distribution system protects the public and itself from unsafe voltage and current levels and significantly reduces the impact experienced by customers due to grid issues.

DESCRIPTION

The capabilities offered through DA can transform what may have been an hour-long power outage for hundreds or even thousands of homes and businesses into a momentary outage – or potentially help avoid an outage altogether.

The DA consists of several complementary efforts that work in concert to support dynamic and growing distribution system loads in a more sustainable way while minimizing power quality issues that often accompany a large-scale transition to solar power. One of these projects, **Urban Underground System Automation,** modernizes the protection and control of underground power systems that serve critical high-density areas, such as urban business districts and airports.

The **Fuse Replacement** project focuses on replacing one-time use fuses with automatic operating devices capable of intelligently resetting themselves for reuse, thus eliminating unnecessary use of resources (inventory, time, gasoline, etc.). The **Hydraulic to Electronic Recloser** program replaces obsolete oil-filled (hydraulic) devices with modern, remotely operated reclosing devices that support continuous system health monitoring.

Such digital device upgrades offer further value through efforts like the **System Intelligence and Monitoring** pilot, which develops advanced diagnostic tools that help engineers and technicians address electrical disturbances on the distribution system and improve customer experience.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ IMPROVE RELIABILITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: DISTRIBUTION SYSTEM AUTOMATION (DA)

MORE ABOUT THE PROGRAM

Through its suite of complementary efforts, the DA Program offers a way to deliver electricity to customers while avoiding preventable service interruption for thousands of customers.

Hydraulic to Electronic Recloser

Phases out existing hydraulic (oil-filled) reclosers to reduce the oil footprint and eliminate maintenance activities. The sub-program has two phases: (1) target all hydraulic reclosers rated 140 amps or greater and replace with electronic, solid-dielectric interrupter devices; and (2) focus on smaller hydraulic reclosers (those rated less than 100 amps) and replace them with similar electronic, solid-dielectric, reclosing devices as this technology becomes mature enough for full scale deployment.

System Intelligence and Monitoring Pre-Scale Effort

Leverages data from digital devices deployed as part of the Self-Optimizing Grid, Smart Meter, and other programs to build a database and system model that monitors electrical disturbances across the distribution system. While each grid device may only monitor a portion of a circuit, advanced analytics creates a larger picture of system activity and an end-to-end blended view of customer experience. When completed, this subprogram will create a new system diagnostic tool for troubleshooting problem areas and mitigating emerging issues as they occur, as well as for managing the integration of DER.

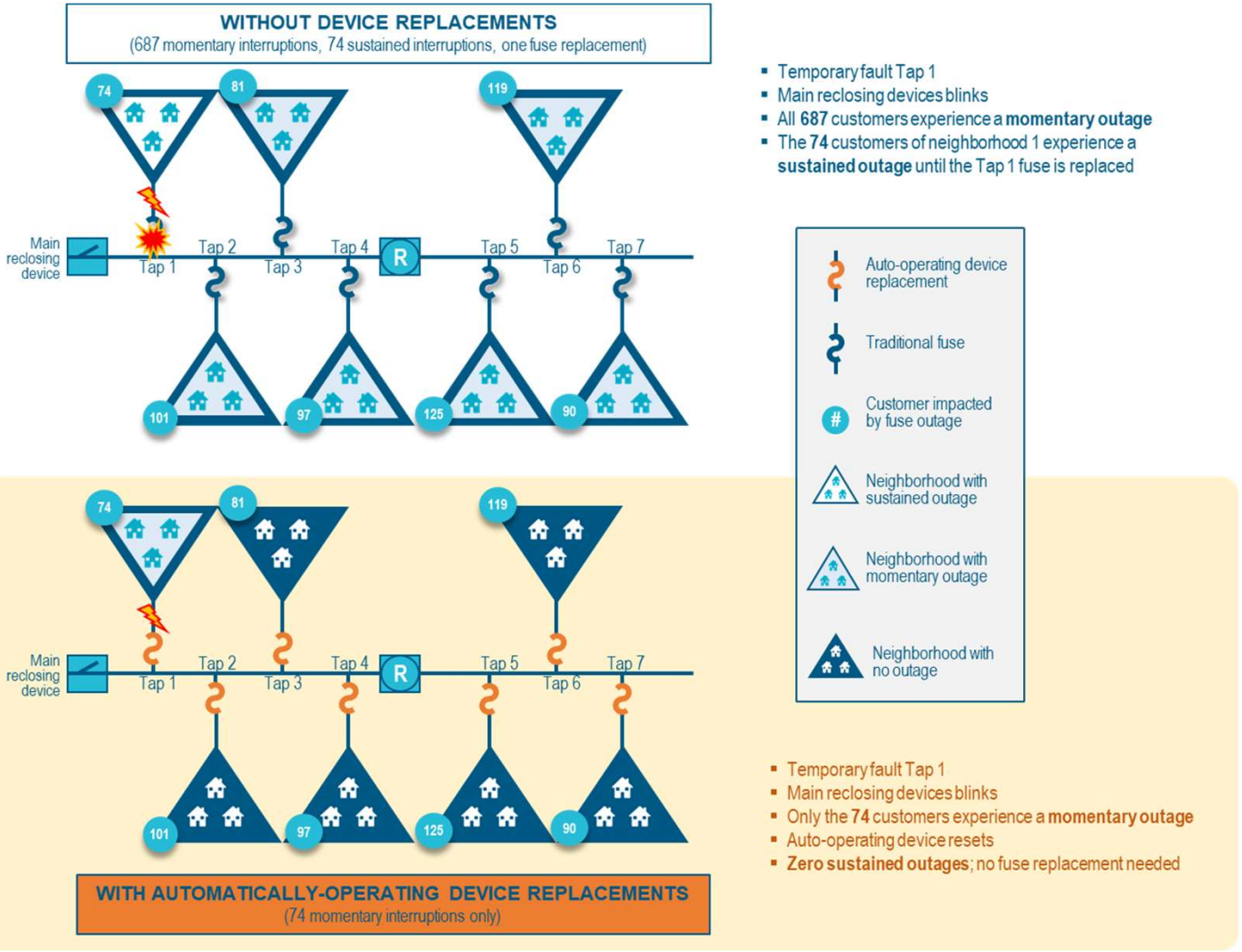
Fuse Replacements with Electronic Reclosers

Replaces protective tap line fuses with small electronic sectionalizing devices on segments that can eliminate the most interruptions for customers. The small electronic reclosers serve to prevent customer outages by allowing temporary faults time to clear power lines before operating and initiating sustained outages. A protective fuse in this same tap line configuration is designed to actuate and initiate a sustained line outage at the first sign of a line fault; it must then be replaced before service can be restored. The fuse replacement with electronic recloser eliminates the mainline breaker from operating at all, eliminating unnecessary momentary interruptions and sustained outages.

Underground (UG) System Automation

Replaces manually operated underground switchgear with remotely operated automated switchgear and deploys advanced automation schemes in urban downtown areas and other places with high density public use, such as airports and public entertainment areas. UG Automation enables automatic reconfiguration of underground systems for connecting to a new feeder or for isolating downstream system faults to minimize customer outages and impacts to the public. When completed, what might have been hours of service interruption can be reduced down to seconds.

PROGRAM: DISTRIBUTION SYSTEM AUTOMATION (DA)



PROGRAM: ENERGY STORAGE

The Energy Storage program implements battery storage and other related non-traditional measures to defer, mitigate, or eliminate the need for traditional utility investments, such as line capacity upgrades.

DESCRIPTION

The program supports customer and utility initiatives through smart investments in storage for applications that deliver value to customers and the company. These applications include microgrid projects for preventing planned and unplanned outages, as well as long-duration outage projects for providing redundant power sources for vulnerable (rural and remote) communities, and circuit and bank capacity projects using substation-tied energy storage.

Given the multiple applications energy storage technology supports, projects within the Energy Storage program are designed and assessed on a case-by-case basis for the specific challenge being addressed (e.g., long duration outage support, microgrid or emergency power support, auxiliary service needs, etc.).

The Energy Storage program also includes the development and deployment of an energy storage control system to manage the fleet of energy storage resources.

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY (DER Enablement)
- ✓ MODERNIZE GRID OPERATIONS & PLANNING
- ✓ EXPAND CUSTOMER OPTIONS AND CONTROL

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: ENERGY STORAGE

MORE ABOUT THE PROGRAM

Energy storage provides several different forms of value when applied to the distribution grid. It can be used as a tool to improve reliability to remote communities and it can help increase the how much DER in the form of solar energy can be connected to the grid. It can also be used as a way to delay or mitigate the need to invest in more traditional resources to address transmission and distribution capacity needs.

Energy Storage Control System (ESCS)

By enabling grid operators to dispatch batteries, and batteries plus solar, as part of a diverse generation portfolio, the ESCS project creates the means for distributed energy resources to provide a more cost-effective, energy storage solutions for enhancing grid efficiency and reliability, along with bulk power operations effectiveness. The primary ESCS applications include: (1) Frequency regulation services, (2) Energy arbitrage (i.e., shifting to charge off-peak, discharge-on peak), and (3) Microgrid islanding for outage support and peak shaving.

Interrelation with Integrated System Ops Planning (ISOP)

Energy storage is a technology that offers the ability to support many valued requirements across the generation, transmission and distribution systems. The Integrated System Operation Planning (ISOP) effort will enable storage and microgrid projects to be deployed more effectively.

Example: Mt. Sterling Microgrid

The Mt. Sterling Microgrid project was developed to provide electric service to a remote customer in a reliable but more cost-effective way than via a traditional distribution feeder. The microgrid option meets customer needs through use of distributed energy resources, while enhancing both safety and productivity for utility workers by mitigating line maintenance activity in a high-risk, labor-intensive environment. With the maturity of energy storage technology, a microgrid with solar and storage components sized to support customer load for seven consecutive days (without solar generation) was designed, assessed, and determined to be a more reliable and cost effective option for meeting the customer's need for service. The solution, a 10-kW solar PV array, a 95-kWh battery energy storage system and remote monitoring system, offers availability 99.95% of time, with 25-year asset life.

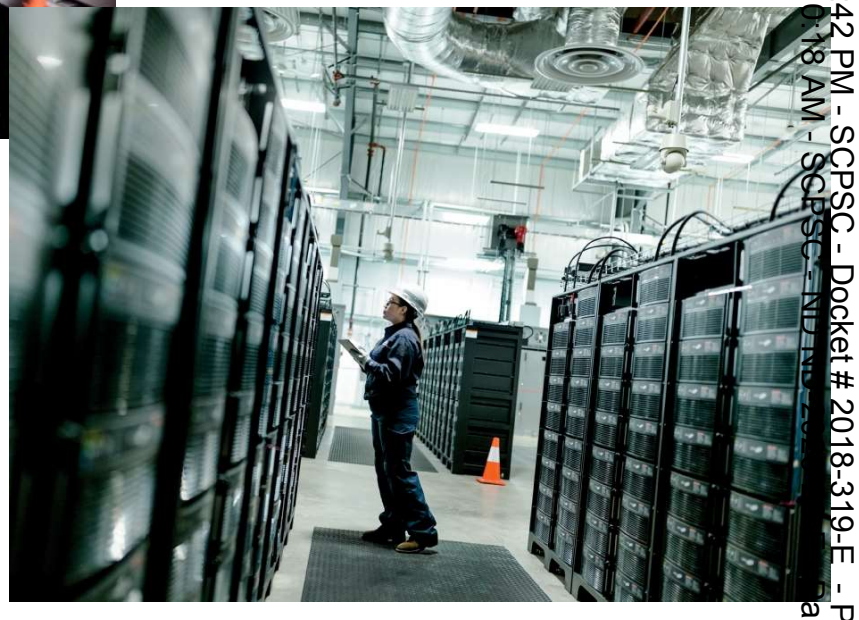
PROGRAM: ENERGY STORAGE

DUKE ENERGY

MCALPINE MICROGRID BATTERY SYSTEM

COMMUNITY BATTERY BACKUP SYSTEM

NOTREES BATTERY STORAGE FACILITY



PROGRAM: LONG DURATION INTERRUPTION / HIGH IMPACT SITES (LDI/HIS)

The LDI/HIS program is designed to improve the reliability for parts of the grid with high potential for long duration outages as well as for high-impact customers like airports and hospitals.

DESCRIPTION

The LDI/HIS program is designed to improve the reliability in parts of the grid where the duration of potential outages is expected to be much higher than average. Focus areas for this program are radial feeds to entire communities or large groups of customers as well as inaccessible line segments (i.e. off road, swamps, mountain gorges, extreme terrain, etc.).

Many of the areas served by these long, rural, single-sourced feeders can experience significant impacts to the local economy and to quality of life when the entire town loses power. Further, operational and repair costs are generally higher than average in these areas due to the special equipment required.

While some sites may include extreme hardening, circuit relocations, new circuit ties and undergrounding, energy storage solutions may offer more cost-effective solutions for improving reliability and managing costs.

The LDS/HIS program is designed to improve the reliability of high- impact customers like airports and hospitals, and high-density areas that could require a variety of infrastructure solutions to improve power quality and reliability. Typical projects include substation upgrades, circuit ties, voltage conversions, and reconductoring.

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ HARDEN FOR RESILIENCY

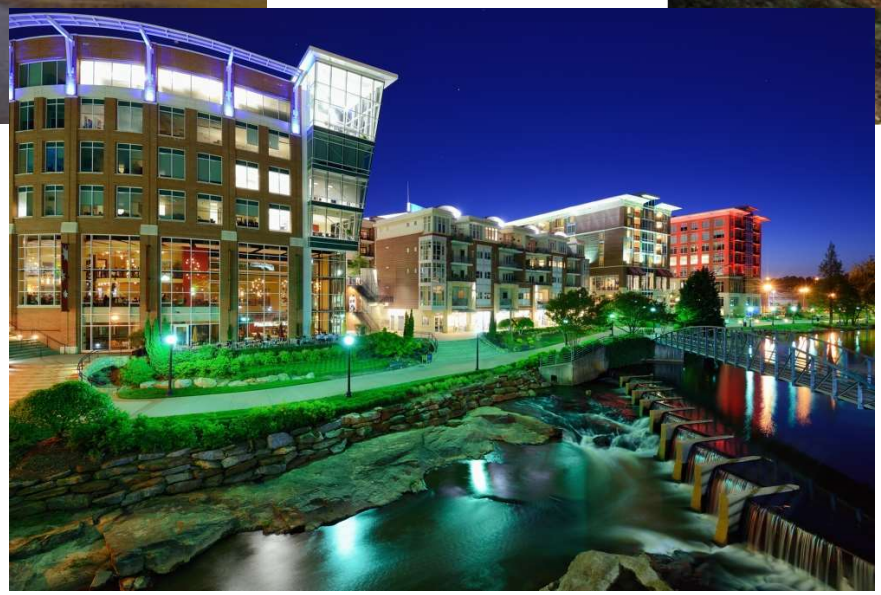
VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: LONG DURATION INTERRUPTION / HIGH IMPACT SITES (LDI/HIS)



DOWNTOWN GREENVILLE, SC

PROGRAM: INTEGRATED SYSTEM OPERATIONS PLANNING (ISOP)

The ISOP program integrates utility planning for generation, transmission, distribution, and customer programs to improve the valuation and optimization of energy resources across the system.

DESCRIPTION

Requirements for modern electric utility systems are evolving rapidly with the advent of emerging new energy technologies, changes in policy, and rapid advancements in information exchange and customer needs. Integrated System Operations Planning (ISOP) focuses on the integration of utility planning disciplines for generation, transmission, distribution and customer programs to improve the valuation and optimization of energy resources across all segments of the utility system to best serve electric customers.

The ISOP process addresses key operational and economic considerations across all segments of the system through integration and refinement of existing system planning tools and, in some cases, development of new analytical tools to assess characteristics that have not historically been captured or considered in long-term planning. Some examples include locational values for distributed resources, system ancillaries and reserves needed to support future operations, and energy resource flexibility to support new dynamic operational demands on the system.

ISOP is a multi-year development program to build the tools and processes needed to accommodate an increasingly integrated approach that will be required to optimize planning and operation of the electric utility system of the future.

GRID CAPABILITIES ENABLED

- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ IMPROVE RELIABILITY
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: TARGETED UNDERGROUNDING (TUG)

The TUG program strategically identifies Duke Energy's most outage prone overhead power line sections and relocates them underground to reduce the number of outages experienced by customers.

DESCRIPTION

Overhead power line segments with a history of unusually high numbers of outages drive a disproportionate amount of momentary interruptions and outages that affect Duke Energy's customers. When these segments of lines fail, they cause problems for Duke Energy's customers directly served by them as well as customers upstream. Lines targeted to be moved underground are typically the most resource-intensive parts of the grid to repair after a major storm. Equipment on these line segments can experience shortened equipment life and additional equipment-related service interruptions.

The goal of the TUG program is to maximize the number of outage events eliminated. Converting outage prone parts of the system enables Duke Energy to restore service more quickly and cost effectively for all customers. Addressing areas with outlier outage performance improves service while lowering maintenance and restoration costs for all customers.

Criteria for consideration in the selection of targeted communities include:

- Performance of overhead lines
- Age of assets
- Service location (e.g., lines located in backyard where accessibility is limited)
- Vegetation impacts (e.g., heavily vegetated and often costly and difficult to trim)

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ HARDEN FOR RESILIENCY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: TARGETED UNDERGROUNDING (TUG)

DOWNED POWER POLES

DAMAGE FROM HURRICANE MATTHEW

LINEMAN IN RAIN

IN AREAS INACCESSIBLE BY BUCKET TRUCK, LINEMEN HAVE TO CLIMB POLES TO MAKE REPAIR

PROGRAM: DISTRIBUTION TRANSFORMER RETROFIT

The Distribution Transformer Retrofit program converts existing overhead distribution transformers to deliver the same reliability benefits as a modern transformer installed today.

DESCRIPTION

Like the Self-Optimizing Grid program, the new sectionalization capability of a retrofitted transformer works to minimize the number of customers impacted by fault or failure on the power line. In addition, similar to the Targeted Undergrounding program, the new protective features that mitigate equipment vulnerabilities work to significantly lower the risk of an outage occurring at the transformer all together.

The core activities of the transformer retrofit program include the installation of a fuse disconnect device on the high-voltage side of every overhead transformer to protect upstream customers from a fault at or downstream of the transformer. In addition, through protective device coordination, the local fused disconnect can be set to prevent any upstream operations of reclosing devices (the source of momentary outages for customers not served by the retrofitted transformer.)

Consistent with modern transformer standards, the program also retrofits transformers with additional protective elements to reduce the risk of external factors such as lightning strikes and animal interference.

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: DISTRIBUTION TRANSFORMER RETROFIT

UN-RETROFITTED CSP TRANSFORMER

RETROFITTED TRANSFORMER

FUSED CUTOUT, ANIMAL GUARDS,
COVERED LEAD WIRE, NEW ARRESTER.

PROGRAM: DISTRIBUTION HARDENING & RESILIENCY – FLOOD HARDENING

The Distribution H&R – Flood Hardening program will be targeted to areas where an overlay of actual outage events from Hurricanes Matthew and Florence intersect with the 100-year flood plan.

DESCRIPTION

In hurricane events like Hurricane Floyd and more recently Hurricanes Matthew and Florence, significant flooding was a major factor impacting restoration. Smart, targeted investments can mitigate the scale of impacts on communities and customers adjacent to these areas prone to extreme flooding. Hardening lines and structures is a balanced approach that can keep power and critical services available to some portion of a community and prevent a widespread outage in an area until flooding recedes.

This program includes the following:

- Alternate power feeds for substations in flood-prone areas, and for radial power lines that cross into and through flood-prone areas
- Hardened river crossings where power lines are vulnerable to elevated water levels during extreme flooding
- Improved guying for at-risk structures within flood zones

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ HARDEN FOR RESILIENCY
- ✓ IMPROVE PHYSICAL SECURITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: DISTRIBUTION HARDENING & RESILIENCY – FLOOD HARDENING

MORE ABOUT THE PROGRAM

Data analytics and geo-spatial analysis will assist Duke Energy in identifying patterns of repeat flood impact issues and allow a targeted basis for assessing hardening investments with a cost benefit analysis approach that delivers savings to Duke Energy customers and, at the same time, enhanced reliability for these flood-prone areas.

For a three-year window, this program will focus on hardest hit flood-prone areas from Hurricanes Matthew and Florence, defining opportunities to accomplish the following:

- Event elimination where hardening can demonstrably eliminate future outages events and repair work
- Resiliency options to re-route power and keep many people supplied with power while repairs to damaged facilities are made.

This program will be coordinated with other programs to ensure work scopes do not overlap.

PROGRAM: DISTRIBUTION HARDENING & RESILIENCY – FLOOD HARDENING

GOLDSBORO FLOODING DURING HURRICANE MATTHEW

FLOODING OF A SUBSTATION IN GOLDSBORO FOLLOWING HURRICANE MATTHEW (2016)

PROGRAM: SMART METERING INFRASTRUCTURE

The Smart Meter program is a metering solution (meters, communication devices and networks, and back office systems) used to create two-way communications between customer meters and the utility.

DESCRIPTION

Smart meters are digital electricity meters that have advanced features and capabilities beyond traditional electricity meters. Some of the advanced features include the capability for two-way communications, interval usage measurement, tamper detection, voltage and reactive power measurement, and net metering capability.

Duke Energy's standard smart meter system utilizes a radio frequency ("RF") mesh architecture, which is flexible in that the meters within the mesh network establish an optimized RF communication path to a collection point either through other meters, through network range extenders, or via a direct cellular connection.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ EXPAND CUSTOMER OPTIONS AND CONTROL

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: SMART METERING INFRASTRUCTURE

PROGRAM: ELECTRIC TRANSPORTATION

The Electric Transportation effort is a proposed pilot program for South Carolina that will focus on advancing adoption of electric transportation in the State.

DESCRIPTION

The program will establish a foundational level of fast charging infrastructure and determine best practices for cost-effective integration of various electric vehicle types. It will also serve to financially support the deployment of electric school and transit buses in conjunction with the 2016 Volkswagen settlement agreement.

The program will also allow system planners to assess the impacts of charging different types of electric vehicles, as well as impacts that various charging configurations have on the electric system.

In addition to evaluating grid impacts, the Electric Transportation pilot program will assess how all utility customers can benefit from increasing adoption of electric transportation. The pilot program will consist of five components: (1) Residential EV Charging Rebate, (2) Electric Vehicle School Bus Program, (3) Electric Vehicle Transit Bus Program, (4) DC Fast Charging Infrastructure Program, and (5) Education and Outreach.

Another benefit to advancing electric transportation is improved air quality by displacing hydrocarbon based fuels and lowering emissions.

GRID CAPABILITIES ENABLED

- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ INCREASE HOSTING CAPACITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING
- ✓ EXPAND CUSTOMER OPTIONS AND CONTROL

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: ELECTRIC TRANSPORTATION

MORE ABOUT THE PROGRAM

In 2011, Duke Energy conducted a plug-in electric vehicle charging station pilot in DEC. This pilot provided charging stations and up to $1,000 credit toward installation for customers who bought or leased a plug-in electric vehicle. Duke Energy analyzed the distribution impact and ways to mitigate those impacts as electric vehicles come into its service territory; the technical capabilities that the charging stations can offer to help mitigate those potential impacts; and when, where, how long, and how often a customer charges their electric vehicle.

Fast Charging Deployment Needed for Market Growth

Electric vehicles are coming to South Carolina as sales growth through the end of 2017 continued with a compound annual growth rate of 43% since 2011. Lack of charging stations is commonly cited as a barrier to purchasing an EV. The program estimates that approximately 1,000 public direct-current fast charging ("DCFC") plugs will be necessary by 2025 to support current forecasts of EV market growth. Currently, there are only 40 open-standard, publicly available DCFC plugs in South Carolina.

Volkswagen Environmental Mitigation Trust

In 2016, Volkswagen agreed to spend up to $14.7 billion to settle allegations of cheating emissions standards. Of that amount, $2.9 billion was used to establish an Environmental Mitigation Trust, which states and U.S. territories may use to invest in transportation projects that will reduce NOx emissions. Of that amount, $34 million was allocated to South Carolina as a beneficiary under the Settlement Trust. In April 2018, the SCDOI announced the release of the first draft of the state's Beneficiary Mitigation Plan ("BMP"). Eligible mitigation actions under the BMP include replacing or repowering diesel school buses, shuttle buses, or transit buses. In addition, beneficiaries may utilize up to 15% of their total allocation on costs relating to light duty, zero-emission vehicle supply equipment.

Other States Are Embracing Electric Vehicles

The Florida PSC approved an EV Infrastructure Pilot proposed by DEF, including public Level 2 and DC Fast Charging; in New York, ConEdison is supporting the deployment of electric school and transit buses, planned fast charging networks, and residential customer charging research. In Orlando, Florida, the Orlando Utilities Commission has deployed one of the largest municipal EV infrastructure programs in the country. Other examples of states that have embraced EVs in a pilot or otherwise include Maryland, Massachusetts, Oregon, Kentucky, Ohio, and California. Georgia Power has installed 25 public fast charging stations, facilitating EV adoption across the state of Georgia. By installing DC Fast Charging stations in South Carolina, the ET Pilot would build on this neighboring network and allow EV drivers to seamlessly traverse South Carolina along the crucial I-85, I-95, and I-26 interstate corridors.

PROGRAM: ELECTRIC TRANSPORTATION

PROGRAM: CUSTOMER DATA ACCESS

The Customer Data Access program focuses on preparing key data systems for sharing data in a manner that aligns with prevailing data access protocols such as the Green Button standard.

DESCRIPTION

Currently, the Company offers a method for customers to download their trailing energy usage data into an XML format. The Customer Data Access program will incorporate modern data access protocols such as the current "**Green Button-Download My Data**" functionality.

"**Green Button-Connect My Data** (CMD)" is a regular automatic transfer of a customer's interval usage data to a third party upon authorization by the customer. The Customer Data Access program will evaluate deployment of CMD or functionality like CMD based on several factors and requirements relevant to South Carolina customers and stakeholders.

GRID CAPABILITIES ENABLED

- ✓ EXPAND CUSTOMER OPTIONS AND CONTROL

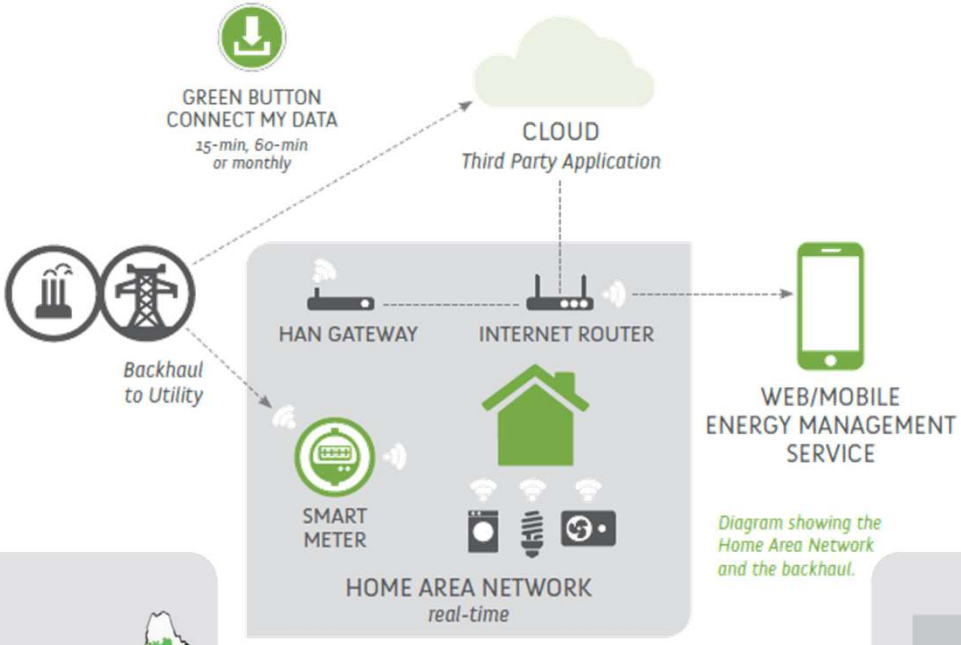
VALUE TO OUR CUSTOMERS

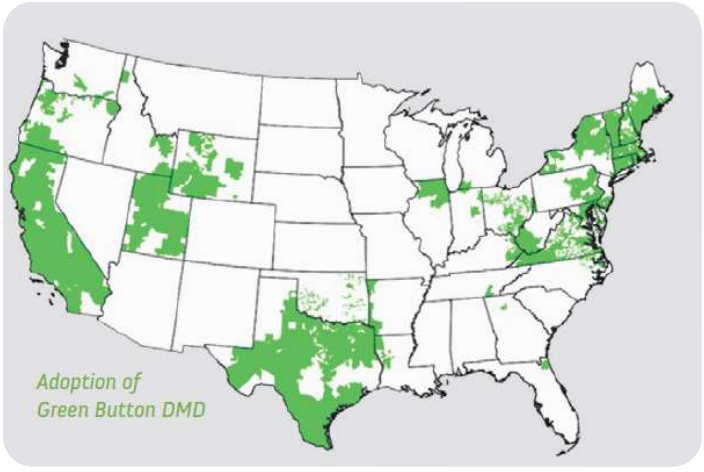
- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

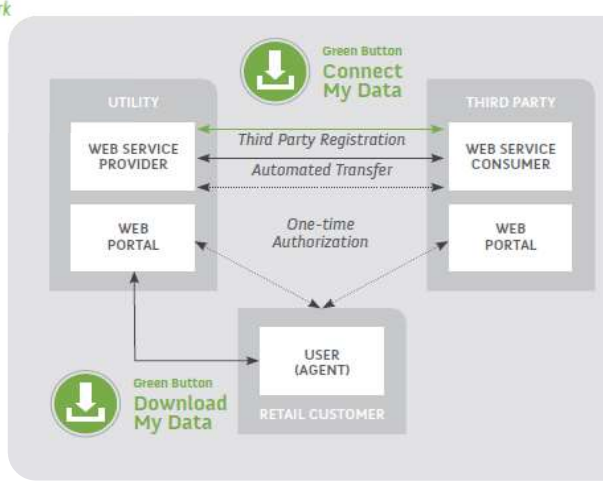
WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: CUSTOMER DATA ACCESS







Source: Murry, M. and Hawley, J., Got Data? The Value of Energy Data Access to Consumers. More Than Smart. January 2016. <Retrieved from http://www.missiondata.org/s/Got-Data-value-of-energy-data-access-to-consumers.pdf>

PROGRAM: TRANSMISSION SYSTEM INTELLIGENCE

The Transmission System Intelligence program deploys transformational system monitoring and control equipment to enable faster response to outages and more intelligent analysis of issues on the grid.

DESCRIPTION

Transmission grid automation improvements will reduce the duration and impacts associated with transmission system issues.

Improvements in transmission system device communication capabilities enable better protection and monitoring of system equipment. The data collected from intelligent communication equipment helps better assess and optimize transmission asset health.

The Transmission System Intelligence program includes 1) the **replacement of electromechanical relays** with remotely operated digital relays, 2) the implementation of **intelligence and monitoring technology** capable of providing asset health data and driving predictive maintenance programs, and 3) the deployment of **remote monitoring and control** functionality for substation devices, and rapid service restoration.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: TRANSMISSION SYSTEM INTELLIGENCE

MORE ABOUT THE PROGRAM

System Intelligence and Monitoring

This subprogram focuses on a machine-learning platform that can determine when equipment maintenance or repair is needed. Health and Risk Monitoring (HRM) of the transmission system allows asset managers to proactively address equipment issues before catastrophic equipment failures occur. The HRM platform utilizes Condition Based Monitoring (CBM) – the continuous remote monitoring of asset health data which is used to extend asset life or execute mitigating activities to prevent equipment failures. HRM supplements CBM data with information from Digital Fault Recorders (DFR), which record the details of transmission system faults to support the types of post-fault event analysis that drives future system performance improvements.

Electromechanical to Digital Relays

This subprogram replaces noncommunicating electromechanical and solid state relays with digital relays. Modern relay design with communications capabilities and microprocessor technology enables quicker recovery from events than the design of the existing electromechanical relays. One digital relay is capable of replacing a variety of legacy single-function electromechanical relays. Two-way communications and event recording capabilities allow them to provide device performance information following a system event to support continuous system design and operational improvements. Additionally, they identify line fault locations, which is the ability to use device data to calculate the distance down a line to a line fault, rather than manually assessing and patrolling transmission lines.

Remote Substation Monitoring

This subprogram enables operators to remotely monitor and control substations. This includes the installation or upgrade of supervisory control and data acquisition system (SCADA) interfaces for substation devices, called remote terminal units (RTUs), and upgrades to associated data communication channels. This subprogram is a critical enabler for programs like Integrated Volt/Var Control and Distribution Automation. This subprogram also upgrades serial communication to IP communication for existing RTUs to collect more data and support more devices.

Remote Control Switches

This subprogram replaces non-communicating switches with modern switches enabled with SCADA communication and remote control capabilities. Transmission line switches are currently manually operated in most substations and cannot be remotely monitored or controlled. Switching, a grid operation often used to section off portions of the transmission system in order to perform equipment maintenance or isolate trouble spots to minimize impacts to customers, has historically required a technician to go to a substation and manually operate one or more line switches. This subprogram increases the number of remote controlled switches to support faster isolation of trouble spots on the transmission system and more rapid restoration following line faults.

PROGRAM: TRANSMISSION SYSTEM INTELLIGENCE

PROGRAM: TRANSMISSION HARDENING & RESILIENCY (H&R)

The Transmission (H&R) program works to create a stronger and more resilient transmission grid capable of withstanding or quickly recovering from extreme external events, natural or man-made.

DESCRIPTION

Each Transmission H&R sub-program works to address unique challenges in ways that harden the system, and not only minimize impacts to customers, but enhance their electric service experience. The **44-kV System Upgrade** subprogram both protects the 44-kV system from extreme weather, but also paves the way for more DER interconnections by creating additional capacity on the system to transport generation from large scale solar sites. Similarly, the **Targeted Line Rebuild for Extreme Weather** subprogram protects some of the higher voltage transmission lines from extreme weather by addressing vulnerable wooden structures.

The **Networking Radially Served Substations** subprogram builds in more resiliency to the transmission system by creating alternative ways to provide customers with reliable electricity supply in the case of an issue with the primary transmission feed; and, the **Substation Flood Mitigation** subprogram builds in protection for substations most vulnerable to flood damage. Altogether, these H&R efforts not only enhance the functionality of individual assets, but substantially improve the overall functionality of the system, particularly under extreme weather conditions. The long-term plan for hardening and resiliency is to relocate or strengthen at-risk assets or other solutions such as raising the flood plane at that site.

GRID CAPABILITIES ENABLED

- ✓ IMPROVE RELIABILITY
- ✓ HARDEN FOR RESILIENCY
- ✓ IMPROVE PHYSICAL SECURITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: TRANSMISSION HARDENING & RESILIENCY (H&R)

MORE ABOUT THE PROGRAM

44kV System Upgrades

Rebuilds and upgrades targeted portions of the 44-kV system to both harden the system against extreme weather, position the system to support DER, and make the overall system more resilient. This will be accomplished in three phases:

- PHASE I (infrastructure upgrades): structurally rebuilds the system, replacing wood structures with taller/stronger steel or concrete structures to better withstand damage in extreme weather conditions. Rebuilding 44-kV lines to 100-kV standards improves performance due to greater elevation and clearance from vegetation. The increased conductor spacing between each of the phases and the addition of basic insulation decreases impacts of lightning events.
- PHASE II (voltage conversions): converts specific circuits of the 44-kV system to 100-kV, making them more capable of supporting large scale solar, storage and other DER. These conversions also require converting the substations served by these lines, which generally involves installing high rated equipment such as transformers and breakers. Portions of the 44-kV system, particularly in rural areas that are prime locations for utility scale solar development, are capacity constrained and unable to support additional interconnections.
- PHASE III (circuit looping): builds in circuit ties between upgraded and converted circuits. This creates a looped circuit design capable of feeding power to these circuits from other sources, as needed, to provide additional system resiliency.

Networking Radially Served Substations

Increases resiliency of radially served substations where outage duration is higher than average, including: networked lines sectionalized into separate radial lines, and lines designed as radial feeders. Networked radial lines can be re-networked by replacing the conductor with higher ampacity and by upgrading the protective relaying. Lines designed as radial feeders will be networked to existing lines into another substation. Substations served by networked transmission lines can be served from either end of the line and the line can be sectionalized to isolate an interruption and restore the majority, if not all, of customers before the full line is restored.

PROGRAM: TRANSMISSION HARDENING & RESILIENCY (H&R)

MORE ABOUT THE PROGRAM

Substation Flood Mitigation

Systematically reviewing and prioritizing substations at risk of flooding to determine the proper mitigation solution, which may include elevating or modifying equipment in substations or relocating substations altogether.

Targeted Line Rebuilds for Extreme Weather Events

Specific transmission lines require rebuilding to withstand extreme weather (including wind and ice) and mitigate the risk of unplanned outages. Lines are targeted based on risk-advised decisions along with selection criteria including: tower height, tower condition, and age of asset. Proactive replacement of wooden poles to steel poles that comply with the National Electrical Safety Code (NESC) achieve benefits such as protecting extreme weather and reducing O&M costs.

PROGRAM: TRANSMISSION HARDENING & RESILIENCY (H&R)

TRANSMISSION POLE REPLACEMENTS

69 KV WOOD POLE CONSTRUCTION

NEW 69 KV STEEL POLE CONSTRUCTION

PROGRAM: TRANSFORMER BANK REPLACEMENT

The Transformer Bank Replacement program leverages new system intelligence capabilities to target transformers before they fail.

DESCRIPTION

Predictive and proactive replacement programs like Transformer Bank Replacement significantly reduce the impacts and costs of replacement when compared to performing the same work following a catastrophic failure.

The objective of this program is to anticipate future transformer failures and replace those transformers in an orderly fashion, avoiding the cost and customer outage minutes associated with these failures. Catastrophic failures often result in significant oil spills, requiring expensive cleanup and other mitigation. Proactive replacement also reduces contingent material inventory needed, since replacements have a 12-24 month manufacturing lead time.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: OIL BREAKER REPLACEMENT

The Oil Breaker Replacement program identifies and replaces oil-filled circuit breakers on the transmission and distribution systems with modern technology.

DESCRIPTION

The purpose of this program is to replace these legacy assets with breaker technology capable of two-way communications and remote operations.

Transmission level oil breakers will be replaced with the modern sulfur hexafluoride gas (SF_6) circuit breaker technology. The medium voltage distribution level oil-filled breakers will be replaced with modern vacuum circuit breaker technology.

The new communication and control capabilities of this modern technology better positions the transmission and distribution systems to work with grid automation systems to better respond to electric grid events. Looking forward, these fast-response gas and vacuum breakers are better suited for protecting circuits with higher solar and other variable energy resource penetration.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY
- ✓ MODERNIZE GRID OPERATIONS & PLANNING

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

OPTIMIZE the total customer experience

PROGRAM: PHYSICAL & CYBER SECURITY

The Physical and Cyber Security program protects against the potential risks and impacts of attacks on the electric grid.

DESCRIPTION

The program focuses on hardening above the standard compliance requirements. Transmission elements of the program include:

- **Transmission substation physical security**
- **Windows-based change outs** to address cyber security standards for older Windows-based relays.
- **Cyber security enhancements for non-bulk electric system substations**
- **Electromagnetic Pulse and Intentional Electromagnetic Interference (EMP/IEMI) Protection**

At the distribution system level, much of the focus involves securing and improving risk mitigation of remotely controlled field equipment. An example is enabling door alarms and entry notifications. Programs include:

- **Device Entry Alert System** (DEAS)
- **Distribution Line Device Cyber Protection**
- **Secure Access Device Management** (SADM) - a single tool to remotely and securely perform device management activities and event record retrieval on the entire transmission and distribution device inventory.

GRID CAPABILITIES ENABLED

- ✓ HARDEN FOR RESILIENCY
- ✓ IMPROVE CYBER SECURITY
- ✓ IMPROVE PHYSICAL SECURITY
- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

PROTECT to reduce threats to the grid

PROGRAM: PHYSICAL & CYBER SECURITY

MORE ABOUT THE PROGRAM

Transmission Substation Physical Security

This subprogram enhances the grid resiliency as part of the overall Transmission Security program. Tier 1 site enhancements include high security perimeter fencing and lighting, intrusion detection technology, new security enclosure buildings, hardening of existing control houses, security cameras, and access control. Tier 2 site enhancements include high security perimeter fencing and lighting.

Windows-based Unit Change Outs

The Windows-based Unit Change Outs effort replaces older Windows-based relays that cannot be upgraded due to technology constraints (such as insufficient memory or relay condition). Following these upgrades, the new devices will operate in a Linux environment and be compliant with standards.

Cyber Security Enhancements for non-BES

Cyber Security Enhancements for non-bulk electric system (BES) substations implements protective measures against possible cyber-attacks at those non-BES substations that have Internet-Protocol (IP) routable devices. Such measures include the installation of firewalls and the replacement of vulnerable devices.

EMP/IEMI Protection

Electromagnetic pulses (EMP) and Intentional Electromagnetic Interference (IEMI) can create disruptions for electronic equipment. The measures taken to protect against them focus on hardening and protecting targeted equipment. The electric industry is engaged in significant research, led by the Electric Power Research Institute (EPRI), focused on improving cost-effective and feasible mitigation against EMP/IEMI. This subprogram will focus on pre-scaled implementation of industry research findings.

PROGRAM: PHYSICAL & CYBER SECURITY

MORE ABOUT THE PROGRAM

Device Entry Alert System (DEAS)

The Device Entry Alert System (DEAS) project will install an entry door alarm head-end system and deliver processes to enhance physical and cyber security on the distribution systems' intelligent electronic devices (IEDs). This tool will ensure that all physical access of IEDs and related infrastructure in the field are being tracked and monitored.

Secure Access and Device Management (SADM)

SADM provides a tool to remotely and securely perform device management activities and event record retrieval on our entire device inventory in transmission and distribution. The goal of the project is to improve the security of field devices and increase compliance with North American Electric Reliability Corporation critical infrastructure protection (NERC CIP) and other security requirements.

SADM also provides process and labor efficiencies associated with device management, and improves post-event resolution. Within this program, we will standardize systems and processes for secure remote access to field devices, implement device management tasks (including password management, firmware management, configuration management), manage post-fault and other operational event records, and implement a common solution and support model across all jurisdictions within transmission and distribution.

Distribution Line Device Cyber Protection

The Distribution Line Device Cyber Protection projects address physical and cyber security risks for thousands of SCADA-controlled line devices (e.g., regulators, capacitors, reclosers, etc.). The focus of the projects in this workstream is targeted replacement of legacy control equipment with Enterprise Security and Advanced Distribution Management System compliant equipment. The newer installed equipment meets or exceeds Duke Energy Industrial Control System (ICS) enterprise security requirements and also provides a platform for future asset management enhancements, such as remote firmware and device settings management, reducing the need to travel physically to a site to perform a system upgrade. Examples of equipment being replaced include capacitor and distribution (recloser) control devices.

PROGRAM: PHYSICAL & CYBER SECURITY

COCHRANE FENCE & MAIN ENTRANCE CRASH GATE

PROGRAM: ENTERPRISE COMMUNICATIONS ADVANCED SYSTEMS

The Enterprise Communications program modernizes and secures the critical communications between intelligent grid management systems, data and controls systems, and sensing and control devices.

DESCRIPTION

The program addresses technology obsolesce, secures vulnerabilities, and provides new workforce-enabling capabilities. This program includes improvement and expansion of the entire communications network from the high-speed, high-capacity backbone fiber optic and microwave networks to the wireless connections at the edge of the grid. These upgrades help build the secure communications required for the increasing number of smart components, sensors, and remotely activated devices on the transmission and distribution systems.

Key communication efforts are: (1) **Mission Critical Transport** which strategically upgrades the infrastructure required for high-speed, reliable, sustainable, interoperable communications for grid devices and personnel; (2) **Grid Wide Area Network (Grid WAN)** which improves network reliability, performance and security for current grid management/control applications; (3) **Mission Critical Voice** which replaces current Land Mobile Radio systems with enhanced, reliable, sustainable, interoperable communications across all service territories; and (4) **Next Generation Cellular** which replaces obsolete 2G/3G cellular technology with the more reliable and secure 4G/5G technology required for modern grid devices in the field.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ IMPROVE RELIABILITY
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ IMPROVE CYBER SECURITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: ENTERPRISE COMMUNICATIONS ADVANCED SYSTEMS

MORE ABOUT THE PROGRAM

Mission Critical Transport

Implements the strategic advancements to the backbone of the communication network to ensure reliable, sustainable, interoperable communications for grid devices and personnel. Replaces end-of-life fiber cable, optical systems, and microwave systems; strategically expands high-capacity fiber to new, targeted routes; and investigates alternatives for faster or more cost-effective fiber deployments.

Business Wide Area Network

Updates data network architecture to improve reliability and performance of the core business. Assesses capacity and redundancy requirements and evaluates network options for the core business network and associates area network structures. Supports growing demands for workforce mobility, real-time video capture, data transport needs, and mitigating communication network congestion.

Grid-wide Area Network (Grid WAN)

Improves network reliability, performance and security for grid control, O&M applications by replacing end-of-life data network hardware and converting substations to an IP network architecture. Employs a network redesign, providing capacity and resiliency, and positioning the network to support Field Area Network (FAN) and Neighborhood Area Network (NAN) needed for enabling a smart cities future.

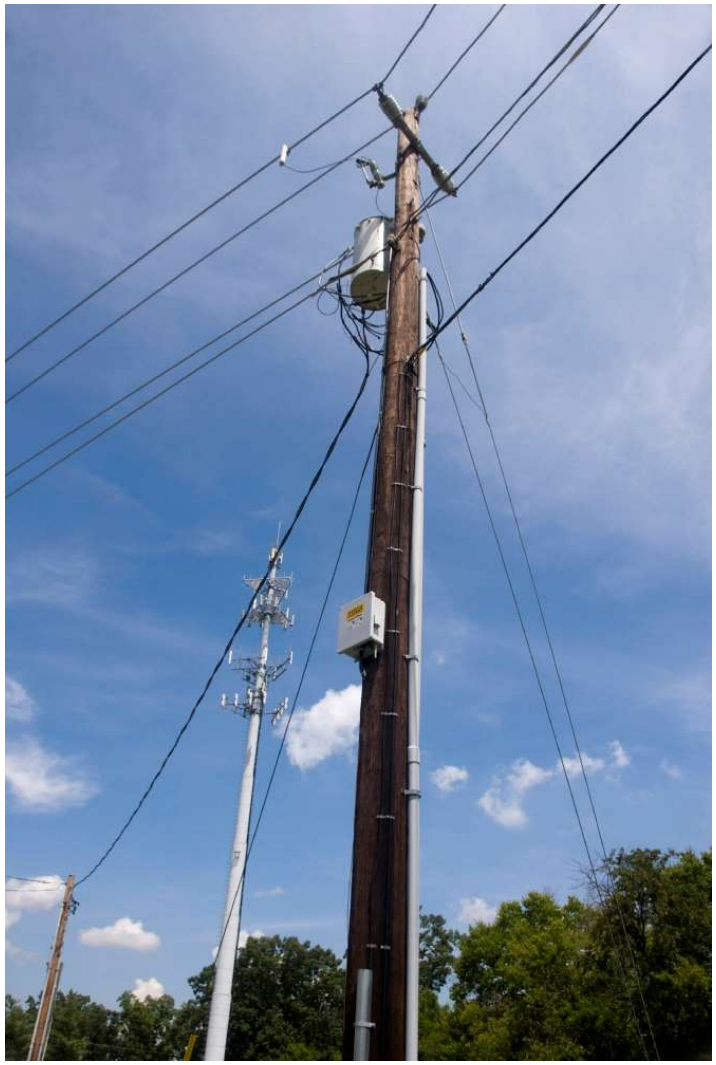
Mission Critical Voice

Strategic replacement and improvement of mission-critical voice (radio) communications to provide reliable, sustainable, interoperable communications for all jurisdictions and businesses. The new radio system will provide increased functionality and interoperability between regions, allowing field workers to use the same radio system to help another region during major storms.

Next Generation Cellular

Addresses the need to migrate 2G/3G communication networks (to be decommissioned by cellular service providers) to updated 4G/5G. Replaces existing network devices located on distribution line devices. In addition to supporting communication continuity through network decommissioning, these upgrades provide greater network bandwidth, lower data latency, and better cybersecurity protection.

PROGRAM: ENTERPRISE COMMUNICATIONS ADVANCED SYSTEMS



PROGRAM: ENTERPRISE APPLICATIONS

The Enterprise Applications program deploys the systems and upgrades needed to monitor the health and security of the grid and analyze data to enable grid automation and optimization technologies.

DESCRIPTION

Upgrades to existing enterprise applications enable system optimization and overall better system performance. Within the program, there are two main components responsible for the delivery of enterprise technology solutions that support transmission, distribution, and other critical lines of business: (1) **Enterprise Systems** and (2) **Grid Analytics**.

This effort focuses on delivering transformative, cross-functional technical solutions to the enterprise in non-disruptive ways. Elements within the portfolio include the Integrated Tools for Outage Applications (iTOA), which works to drive standardization and coordination of grid control center tools and the Targeted Undergrounding (TUG) System, which facilitates efficient workflows via asset management and mapping system upgrades.

Grid Analytics optimizes the electric system health and performance through the deployment of the Health Risk Management (HRM) tool and Enterprise Distribution System Health (EDSH) tool. These tools help to prevent equipment failures and improve asset performance on the transmission and distribution systems, respectively.

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE AUTOMATION
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ IMPROVE RELIABILITY
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ IMPROVE PHYSICAL SECURITY

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: ENTERPRISE APPLICATIONS

MORE ABOUT THE PROGRAM

Integrated Tools for Operations Application (ITOA)

ITOA is a new platform that optimizes current processes and drives standardization regarding system functionality, work processes, and configuration. This project also upgrades and consolidates outage coordination as well as planned switching and logging applications for transmission and distribution control centers.

Targeted Undergrounding (TUG) System

The TUG System automates manual processes and facilitates faster and more efficient workflow by integrating asset management systems. The product enhances the existing enterprise systems for tracking TUG work and creates new mapping capabilities. The mapping enables visualization of the ongoing targeted underground work and consistency in reporting.

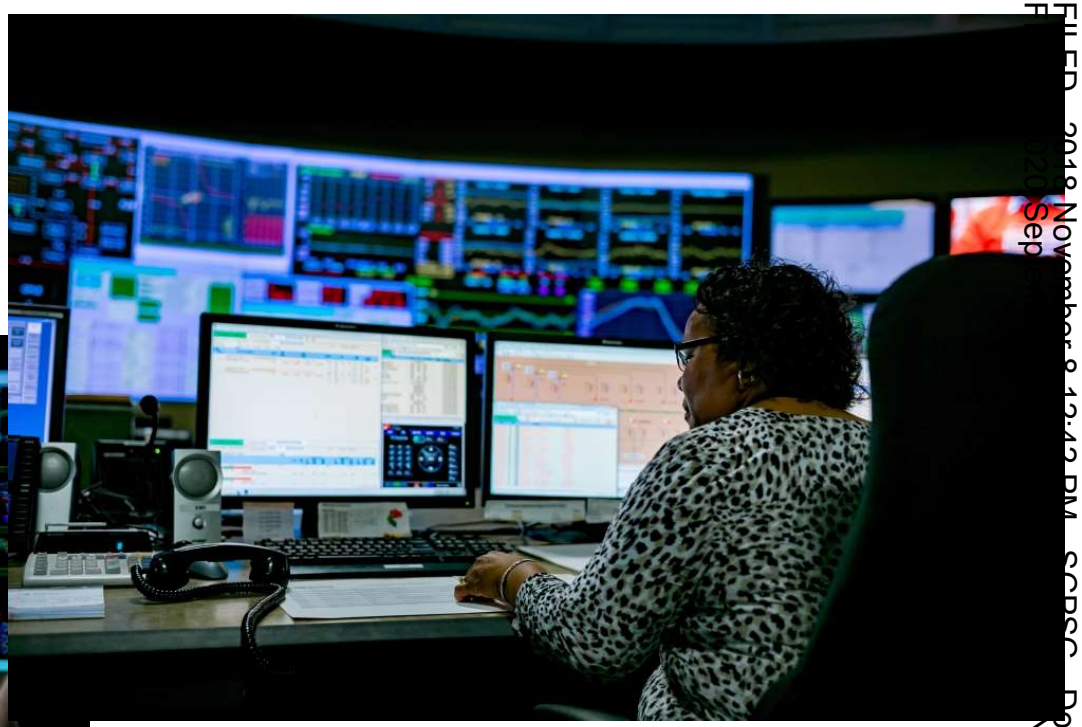
Health and Risk Management (HRM)

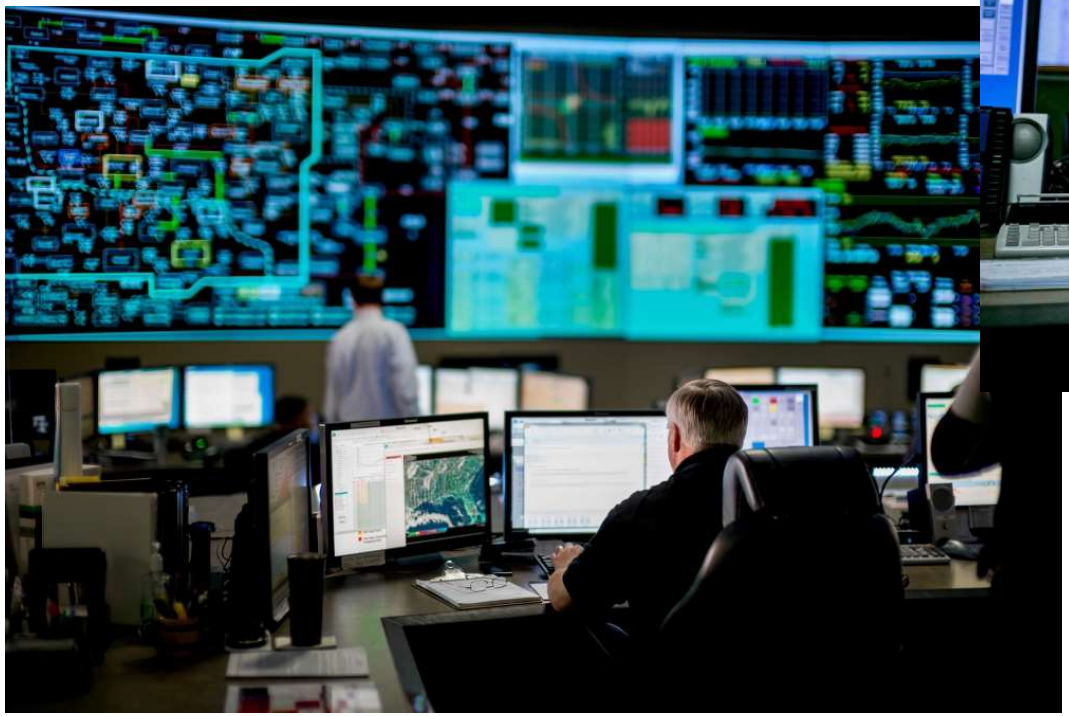
HRM will provide a new platform for collecting data and applying analytics optimization for managing transmission system assets. This sub-program will collect and analyze data to improve the management of assets by using predictive and prescriptive analytics and take proactive steps to prevent or mitigate disruptive events..

Enterprise Distribution System Health (EDSH)

EDSH provides a platform that enables PQR&I Planning, Governance, and Customer Delivery to improve reliability and customer satisfaction. It will enable customer-centric reliability planning and provide a basis for optimizing investments using predictive and prescriptive analytics and allow Duke Energy to take proactive steps to prevent or mitigate disruptive events.

PROGRAM: ENTERPRISE APPLICATIONS





PROGRAM: DER DISPATCH ENTERPRISE TOOL

The DER Dispatch Enterprise Tool is a software-based solution that provides operators with the ability to monitor and manage both transmission and distribution connected DERs.

DESCRIPTION

This tool will coordinate with the Distribution Management System (DMS) and Energy Management System (EMS) to improve the way DERs are integrated in the energy supply mix, both at the Distribution and the bulk power level.

By providing system-wide visualization and control of large-scale DERs, the DER Dispatch Tool will enable system operators to model, forecast, and dispatch a portfolio of distributed energy resources, like solar generation, biofuel generation and energy storage, based on system conditions and real-time customer demand. This tool will help meet the need to match energy demand with supply, especially in emergency conditions.

Current processes and tools provide system operators with a rudimentary ability to quickly shed large blocks of solar generation in emergency conditions to meet standards for real power control (BAL-001-2). The proposed solution will provide operators with a more automated and refined toolset to optimize management of both utility and customer owned DERs to meet system stability requirements.

This system will replace an existing tool in DEP that is used to dispatch distribution connected solar in 50 MW increments

GRID CAPABILITIES ENABLED

- ✓ INCREASE MONITORING & VISIBILITY
- ✓ INCREASE DISTRIBUTED INTELLIGENCE
- ✓ ENABLE VOLTAGE CONTROL
- ✓ ACCOMMODATE TWO-WAY POWER FLOWS
- ✓ EXPAND CUSTOMER OPTIONS AND CONTROL

VALUE TO OUR CUSTOMERS

- ✓ MAINTAIN REASONABLE RATES
- ✓ IMPROVE RELIABILITY, SAFETY, RESILIENCY
- ✓ MEET OR EXCEED CUSTOMER EXPECTATIONS

WHERE IT FITS IN OUR PLAN

MODERNIZE by leveraging enterprise systems and technology advancements

PROGRAM: DER DISPATCH ENTERPRISE TOOL